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THE BUSINESS MODELS OF INTERNET OF THINGS APPLICATION ENABLEMENT PLATFORMS

Master's Thesis
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Abstract of master's thesis

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Abstract

The Internet of Things (IoT) is the next phase in the evolution of the internet, where everyday objects are connected to the internet, and obtain the capacity to communicate with other devices and sense their environment. It is an important phenomenon, which not only has drastic ramifications for the business world, but for everyday life as well. However, there is a lack of literature covering IoT business models, i.e. how different applications of IoT can be transformed into ways of creating, delivering and capturing value. This thesis reviews previous research on IoT business models, and addresses the research gap by examining the business models of IoT application enablement platforms. IoT application enablement platforms have a crucial role within IoT as the middleware that connects the devices to applications and enterprise IT systems.

The business models of IoT application enablement platforms are studied through qualitative interview research, which allowed the discovery of the most important elements of these business models. These elements were found through an inquiry into the most important business model building blocks and their respective types, which are the sub-elements inside each building block. Furthermore, the findings are juxtaposed with previous research about the business models of generic IoT applications. This comparison shows how the business models of IoT application enablement platforms differ from those that have been developed around generic IoT applications. The thesis also describes the theoretical implications, which pertain to previous research about IoT, and other auxiliary phenomena.

The results of the study show the business model building blocks and types, which are the most important for the business models of IoT application enablement platforms. Furthermore, the differences between the business models of IoT application enablement platforms and generic IoT applications are reviewed. The study finds that value propositions and customer relationships are the most important building blocks for the business models of both IoT application enablement platforms and generic IoT applications. Furthermore, the business models of the two are mostly dissimilar as there are few types, which are important for the business models of both IoT application enablement platforms and generic IoT applications. While further research into IoT business models is needed, IoT practitioners can utilize the findings of this study as a reference for how an IoT business model can be configured.

Keywords Internet of Things, IoT, Business Model, Platform Business

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Asioiden Internet on seuraava internetin kehitysaste, jossa tavallisia esineitä yhdistetään internettiin. Tämän lisäksi näille esineille annetaan kyky viestiä keskenään ja havainnoida ympäristöään antureiden avulla. Asioiden Internet on tärkeä ilmiö, mutta sen eri sovellusten ympärille rakennettuja liiketoimintamalleja on tutkittu vain vähän. Tämä pro gradu –tutkielma paikkaa tätä aukkoa tutkimalla Asioiden Internetin sovellusalustojen liiketoimintamalleja. Näillä sovellusalustoilla on tärkeä rooli Asioiden Internetissä, sillä ne toimivat välikappaleena, joka yhdistää esineet erilaisiin sovelluksiin ja yritysten IT järjestelmiin.

Asioiden Internetin sovellusalustojen liiketoimintamalleja tutkitaan kvalitatiivisen haastattelututkimuksen kautta, mikä mahdollisti niiden tärkeimpien elementtien löytämisen. Tutkimus tarkastelee siis Asioiden Internetin sovellusalustojen liiketoimintamallien tärkeimpiä rakennuspalikoita ja tyyppejä. Nämä tyypit ovat eri rakennuspalikoiden sisällä olevia liiketoimintamallin komponentteja. Tämän lisäksi tutkimustuloksia vertaillaan Asioiden Internetin sovellusten ympärille rakennettuihin liiketoimintamalleihin, jolloin nähdään miten ne eroavat sovellusalustojen liiketoimintamalleista. Löydökset kertovat myös muista teoreettisista havainnoista, jotka tehtiin Asioiden Internettiin ja siihen liittyviin ilmiöihin liittyen.

Tutkimuksen tulokset osoittavat ne liiketoimintamallin rakennuspalikat ja tyypit, jotka ovat tärkeimpiä Asioiden Internetin sovellusalustoille. Tulokset osoittavat myös millaisia eroja ja samankaltaisuuksia esiintyy Asioiden Internetin sovellusalustojen ja sovellusten liiketoimintamallien välillä. Näiden liiketoimintamallit eroavat toisistaan, sillä vain harva tyyppi osoittautui tärkeäksi sekä Asioiden Internetin sovellusten liiketoimintamalleille että sovellusalustojen liiketoimintamalleille. Yhtäläistä näiden välillä on puolestaan se, että arvolupaukset ja asiakassuhteet ovat tärkeimpiä liiketoimintamallin rakennuspalikoita molemmille. Asioiden Internetin liiketoimintamalleja tulee vielä tutkia lisää, mutta tämä tutkielma antaa esimerkkejä siitä, miten sellainen voidaan luoda.

Avainsanat Asioiden Internet, Esineiden Internet, IoT, Liiketoimintamallit, Sovellusalustat

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This thesis, and the graduation that follows it, mark the end of my master-level and university studies. Frankly, this degree might also be the final piece of formal education that I will ever do in my life. With this in mind, I would like to thank all the teachers that have guided me over the years, even though most of them will never read these words. I also want to extend my gratitude to all of my interviewees, and my supervisor Matti Rossi, for making this thesis possible. Finally, I want to thank my family and friends for their continued support throughout my academic journey.

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1 Introduction

This thesis explores the topic of Internet of Things (IoT) business models with a focus on the business models of IoT platforms. IoT refers to the next phase in the evolution of the internet, where everyday objects are connected to the internet, and obtain the capacity to communicate with other devices and sense their environment (Mishra et al. 2016; Borgia, 2014). IoT is a current phenomenon that is estimated to have a significant effect on not only the business world, but everyday life as well. Indeed, McKinsey and Company estimate that the monetary impact created by IoT will be the equivalent to approximately 11 percent of the world economy by 2025. Moreover, Cisco and General Electric estimate that IoT will add 15 to 20 trillion USD to the world economy by 2020, respectively. As these estimates illustrate, IoT is poised to have a drastic impact on the world economy, and create a wealth of business opportunities.

Despite the potential of IoT, there is a lack of literature covering IoT business models, and how business models can be created for different IoT applications (Gubbi et al. 2013). This is primarily caused by the novelty of IoT as well as ambiguity about its impact. However, the assessed magnitude of IoT warrants further research, which in turn can help entrepreneurs create IoT business models that create and capture the greatest amount of value possible.

A business model is the way in which a company “creates, delivers and captures value” (Osterwalder and Pigneur 2010), and it describes the operating logic of a company. Business models can be examined from a variety of perspectives, but the most established business model analysis and development framework is the business model canvas, which was developed by Osterwalder and Pigneur (2010). It divides the business model of a company into nine building blocks, which in turn contain different elements that are called types. Thus, the business model of a company can be analyzed by breaking it down into its elements - the nine building blocks and their associated types.

The business model canvas is based on a meta-analysis of business model frameworks (Dijkman et al., 2015), and while other business model frameworks also exist, most of them end up using the same building blocks partially (e.g. Fan and Zhou, 2011; Liu and Jia, 2010) or completely (e.g. Bucherer and Uckelmann, 2011; Sun et al. 2012). For this reason, the business model canvas is also used as the theoretical framework in this study.

This thesis focuses on the business models of IoT platforms, because studying the business models of all IoT applications is beyond its scope. By IoT platforms, the author means IoT application enablement platforms, but the term "IoT platform" is used for the sake of brevity. IoT platforms were chosen as the focus of the study, because they serve a crucial role as the middleware of IoT. Indeed, IoT platforms can be thought of as the "glue" that connects the devices on one side, to the applications and the enterprise IT systems on the other side (Bandyopadhyay et al. 2011; Balamuralidhar et al. 2013). Thus, IoT platforms have a crucial role in fulfilling the IoT vision.

1.1. Research Objectives and Questions

In this thesis, the business models of IoT platforms are studied through qualitative research, which consists of eleven interviews with IoT platforms companies. These interviews were recorded, transcribed and coded, which provided the necessary information for performing the analysis. On an academic level, this thesis seeks to contribute to the understanding of IoT business models and IoT platform business models. On a practical level, this thesis aims to discover insights about IoT business models, which aspiring entrepreneurs can use, when they are configuring their IoT business models. The most important of these is determining the building blocks and types that are the most salient for IoT business models, because these are the elements business models consist of. Thus, understanding the most important building blocks and types shows how IoT business models can be configured, and this understanding can be utilized as a benchmark when new IoT business models are developed.

The focus of the research is on IoT platforms and their business models, but these are also juxtaposed with the business models of generic IoT applications to discern the similarities and differences between the two. Dijkman et al. (2015) studied the business models of generic IoT applications, and their findings are used as the point of reference. Thus, this thesis has two objectives: On one hand, it seeks to discover how business models can be created for IoT platforms, and on the other hand, it studies the differences between the business models of IoT platforms and generic IoT applications. This leads to the two following research questions:

1. Which business model building blocks and types are the most important when developing business models for IoT platforms?

2. How are the business models of IoT platforms different from those of generic IoT applications?

1.2. Thesis Structure

This thesis begins with a literature review that covers the topics of IoT and business models, while also briefly discussing business model development. The literature review also covers the subject of IoT business models, and this discussion is complemented with an explanation of business ecosystems and IoT platforms. These topics are discussed in order to establish a comprehensive theoretical background for the empirical section.

Next, the research methodology is outlined in the methodology section, which is followed by a thorough discussion of the findings. The findings are organized thematically with each one of the business model building blocks being covered in its own sub-section. Each sub-section also includes the comparison between the findings of Dijkman et al. (2015), which shows the similarities and differences between the business models of IoT platforms and generic IoT applications.

Then, these findings are summarized, and discussed in greater depth. The discussion section analyzes the main findings, and explains how the research questions were answered. The discussion chapter also includes a section on the theoretical implications, which the findings have for the phenomena discussed in the literature review. Finally, the limitations of the study and suggestions for future research are provided in the conclusion section, which concludes the thesis.

2 Literature Review

This chapter discusses the theoretical phenomena that pertain to the topic of IoT platforms, with the purpose of laying the foundation for the empirical section that follows. Thus, the literature review gives the reader a necessary understanding about the IoT vision, and its challenges. Furthermore, business models and business model development are discussed as these are necessary for turning an IoT application into an actual business. The chapter also explores the area of IoT business models to show what possibilities IoT yields for business model generation. This is followed by a review of business networks and ecosystems as these were discovered to be important for the business models of today. The chapter concludes with a discussion of IoT platforms, as it is necessary to provide a thorough explanation about the focal subject of the thesis.

2.1. The Internet of Things

There is currently no generally accepted definition for the IoT (Thibodeau, 2014), but the core idea of IoT is that common items such as microwaves, clothing and even pacemakers will be connected to the internet in the coming years (Gubbi et al. 2013; Whitmore et al. 2014). In addition to being connected, the IoT vision holds that everyday objects will obtain the capacity to communicate with other devices and sense their environment (Mishra et al. 2016; Borgia, 2014). As Miorandi et al. (2012) assert, the potential in IoT is created by putting calculation and communication abilities to everyday items. Therefore, IoT can be defined as the next phase in the evolution of the internet, in which objects obtain the ability to communicate, sense and act with each other and their external environment. In addition to consumer items, IoT can also be applied to business settings, and to many different industries such as agriculture, manufacturing, healthcare and logistics (Dlodlo et al. 2012; Markman 2015). Since the aforementioned capabilities yield a degree of intelligence to objects, things connected to the IoT are often called smart or intelligent objects (Andersson and Mattsson, 2015; Fleisch et al. 2014).

The smartness of objects is created by inserting identification, sensing, networking and processing abilities into items and objects (Kortuem et al. 2010; Whitmore et al. 2014). The sensing ability is created through sensors, and these can give objects the ability to not only sense and measure their environment, but also to act on it. This ability to act is referred to as actuating, and it also contributes to the possibilities of IoT. For example, if two cars connected to the IoT are driving in a line on a highway, and the front car has to make a sudden stop, this information can be automatically sent to the other car, which stops. Here, the response time is reduced drastically compared to human response times in similar situations, which improves safety on the road. Furthermore, the thermostat within a factory can communicate with the lathes that cool the factory down, so that they are turned off when the thermostat senses that the temperature is at the desired level, which saves money spent on electricity (Markman, 2015). These examples give but a small illustration of the diverse ways IoT can be used to reduce costs or improve safety. IoT can also be used to create new revenue streams, improve regulatory compliance, and change existing business models (McKinsey and Company, 2015; Borgia 2014; Mishra et al. 2016).

As mentioned in the previous paragraph, a key enabler of IoT is sensor technology (Borgia, 2014; Dlodlo et al. 2012; Miorandi et al. 2012). Sensors are devices, which can detect changes in temperature, light, pressure, sound and motion, and this enables them to understand the world around them (Thibodeau, 2014). In the aforementioned examples, sensors would have been fitted into the cars' brake plates and into the lathes to enable the solutions. Sensor prices have been decreasing in recent years, which has enabled their increased usage. In fact, the average price for a sensor will be 45 cents in 2017, while it was $1.3 in 2004 (General Electric, 2016). However, smaller, lighter, more efficient and more affordable hardware need to be created, if the full potential of IoT is to be realized (Lee, 2015). Other important enablers of IoT include RFID tags, cheap bandwidth, affordable processing capabilities, smartphones and wireless sensor networks (Dlodlo et al. 2012; Goldman Sachs, 2014; Gubbi et al. 2013).

Internet accessibility and controllability of objects is an important development that is made possible through IoT (Stankovic, 2014; Mishra et al. 2016). Internet accessibility is achieved through connecting items to the internet and incorporating the networks to which these different items are connected. Once items can be identified and accessed via the internet, consumers and companies can track products during the entire product lifecycle (Whitmore et al. 2014). This is an improvement to previous possibilities, where products could only be tracked during scan points in the supply chain. Furthermore, remote accessibility allows one to operate devices in environments that are dangerous or difficult to access (Porter and Heppelmann, 2015). Ideally, devices and machines can also be updated and fixed remotely, which saves time and money.

There are currently 10 billion connected devices in the world (Columbus, 2016), and this number is expected to grow rapidly in the coming years. The estimates range from Gartner's estimate of 20.8 billion, and Business Insider's estimate of 34 billion (Columbus, 2016) to Evans' (2011) estimate of 50 billion connected devices by 2020. Vincentelli (2015) estimates that the number of connected objects is going to surpass seven trillion by 2025, with approximately 1000 connected things per person. This may sound like a large figure, but the majority of connected devices will be connected to the infrastructure, with only a minority of connected devices being worn or used by individuals (Harle et al. 2012). Moreover, 99 percent of the objects that can be connected to the internet are still not connected (Evans, 2011). The proliferation of connected devices may ultimately lead to humans being completely immersed in technology, a scenario known as the Immersed Human (Borgia, 2014).

The economic impact of IoT is estimated to be colossal. Indeed, Porter and Heppelmann (2015) state that IoT will bring about the next wave of IT-induced productivity growth for the world economy during a time when the effect of earlier IT innovations has diminished and productivity growth is floundering. The estimates on the economic magnitude differ, partially because there are still many unresolved issues such as data security, privacy, standardisation and interoperability (Dlodlo et al. 2012; Stankovic, 2014). For example, McKinsey and company (2015) posit that the economic impact of IoT will be somewhere between 3.9 trillion USD to 11.1 trillion USD by 2025, and constitute 11 percent of the world economy. Additionally, Cisco and General Electric estimate that IoT will add 15 to 19 trillion USD to the world economy by 2020, respectively (Markman, 2015). While these figures show a great variance in IoT's estimated impact, they illustrate the magnitude IoT is going to have on the world economy.

In addition to smart objects, IoT has many different application areas, from smart cities and smart homes to various different vertical industries such as agriculture, health care, logistics and industrial manufacturing (Markman, 2015; Borgia, 2014). For example, the city of Barcelona has completed a number of IoT projects, which encompass the city's parks, parking spaces, transportation and lighting. By implementing IoT throughout the city, Barcelona has saved $58 million on water, increased parking revenues by $50 million per year and created 47 000 jobs (Gea, 2013; Adler, 2016). In production, manufacturers can observe how much their machines are used, and compare the performance of individual machines (Dijkman et al., 2015). This kind of comparison yields insights on the performance on the factories in which the machines were manufactured, and enables the manufacturer to optimize production.

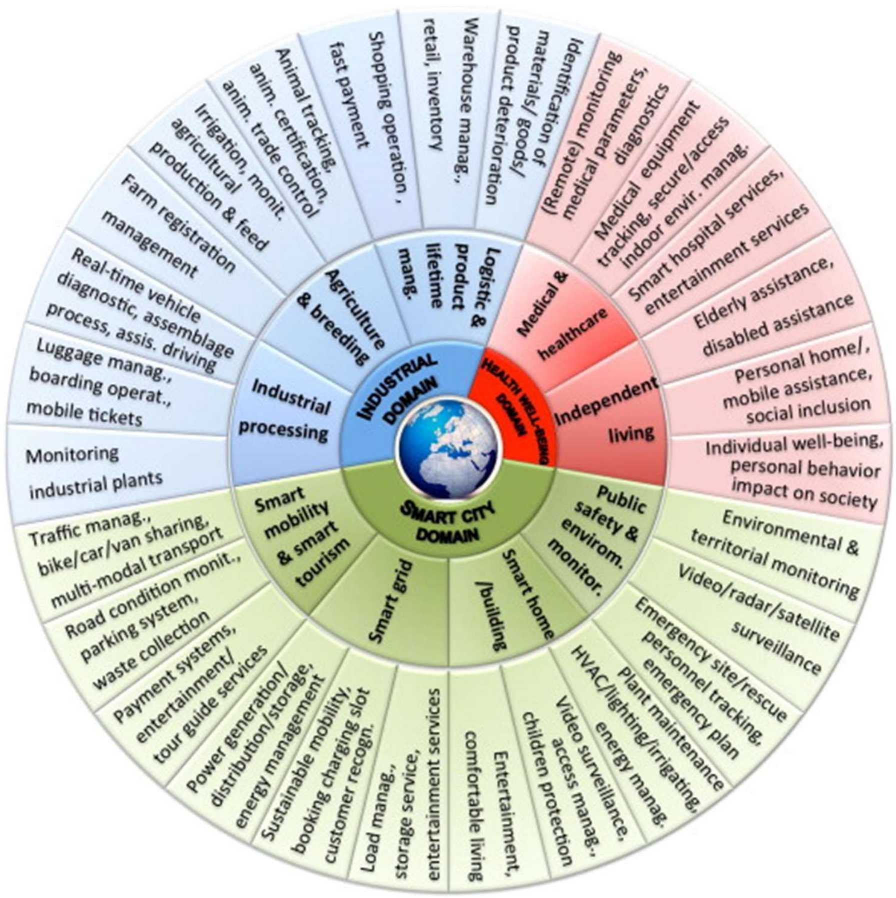

Figure 1: IoT application domains and their related application areas (Borgia, 2014).

Current IoT literature has mostly concentrated on examining IoT research and recommending different applications. Mishra et al. (2016) studied existing IoT literature, and their cluster analysis discovered five clusters in IoT research. The research in the first cluster is mainly theoretical and focuses on reviewing existing literature, and tracing the challenges of IoT (e.g. Atzori et al., 2010, 2012). The second cluster is concerned with implementing IoT in different contexts, e.g. in smart grids (e.g. Yu et al., 2010), while the aim of the third cluster is to explore how IoT can be applied to logistics and supply chains (Luo et al., 2007; Kranz et al., 2010). Authors in the fourth cluster focus on designing IoT (e.g. Katasonov et al., 2008) whereas the fifth cluster focuses on security and privacy and how they relate to IoT (e.g. Zorzi et al., 2010).

While the possibilities of IoT are significant, there are also several challenges that need to be addressed (Borgia, 2014; Miorandi et al. 2012; Zorzi et al. 2010). For example, it will take time until IoT is embraced by end-users, because identification devices that can be used as personal IoT hubs are required (Goldman Sachs, 2014). Smartphones have been proposed as a solution, but current smart phones cannot fulfill this role yet (Bucherer and Uckelmann, 2011). Furthermore, internet accessibility of everyday items raises security concerns, and personal items such as pacemakers have already been hacked into. Beyond personal items, more significant risk scenarios involve a hacker seizing control of a car, an aircraft or a nuclear plant (Porter and Heppelmann, 2015). One of the key challenges in improving IoT security is battery life, because installing more security features requires a greater degree of battery power (Wadhwa, 2012). Nevertheless, the security of both personal and enterprise IoT applications needs to become more robust if IoT is to reach its full potential (Dlodlo et al. 2012).

Another substantial challenge of IoT is privacy, as the vast amount of data generated by IoT raises questions regarding the ownership of this data (Weber, 2010; Whitmore et al. 2014). For example, in a smart home, sensors can collect data on when the tenant is typically present and when different rooms are used. Furthermore, sensors, which have sight and hearing capabilities, can record discussions and provide visual details on security systems (Miorandi et al. 2012; Thibodeau, 2014). Addressing how these data are accessed and who has ownership of them is crucial. Since customer information can be a source of competitive advantage, IoT vendors may feel tempted to consider privacy in loose terms (Thibodeau, 2014).

Interoperability and standardisation issues also present a significant challenge for IoT. There is currently a lack of standards related to IoT, which is an issue, because interoperability of different IoT elements is needed to harness the full power of IoT (Miorandi et al. 2012; Bandyopadhyay and Jaydip, 2011). Indeed, McKinsey and Company (2015) state that interoperability is necessary for obtaining 40-60 percent of capturable value from IoT applications. There are many different IoT elements that need to work together, and these can be classified into hardware (sensors, networks and communication hardware), middleware (data storage and analysis), and presentation (visualization tools that can be used on different platforms) (Gubbi et al. 2013). These elements utilize several technologies, which include peer-to-peer networks, service oriented architecture, cloud computing, RFID tags, Wi-Fi, Bluetooth, wireless sensor networks and near field communication technologies (Borgia, 2014). To give an example of interoperability issues within IoT, I will now explain some of the differences between the last two technologies.

Wireless sensor networks (WSN) and near field communication (NFC) technologies operate at different frequencies, and allow for different speeds of data transfer: WSN operate in the 2.4 Gigahertz area and enables data transfer up to the speed of 250 kilobytes per second, while NFC functions at 13.56 Megahertz and enables a maximum transfer speed of 424 kilobytes per second. They are also used by different devices as WSN are used by environmental and wearable sensors, while NFC is utilized with smart phones and parking meters (Borgia, 2014). The objects within these networks also need to be identifiable, and data transfer between the two networks needs to be possible. This gives an idea of the interoperability challenges between IoT technologies such as WSN and NFC. However, the interoperability issues between the different IoT elements and technologies need to be solved, if the full potential of IoT is to be harnessed (Miorandi et al. 2012; Bandyopadhyay and Jaydip, 2011).

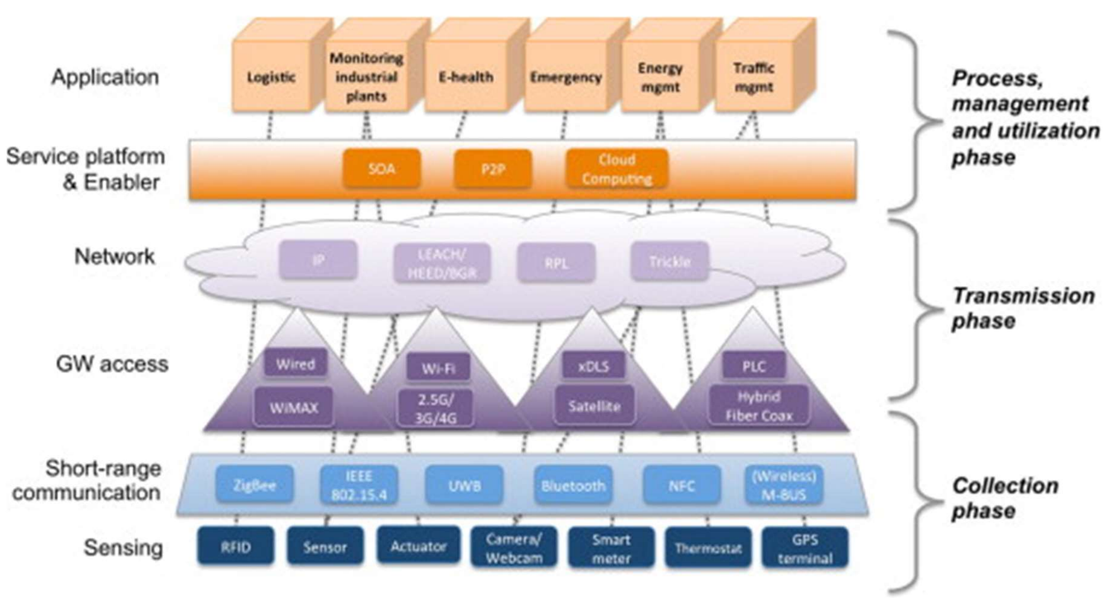

Figure 2: A non-exhaustive list of different IoT elements that need to be interoperable (Borgia, 2014).

Even if interoperability issues between different IoT elements can be solved, there is a risk that IoT sellers may build closed IoT milieus, where only select products will work (Thibodeau, 2014). It remains to be seen how willing companies like Samsung, Bosch or Apple are to develop products, which can connect to each other. In order to prevent fragmentation within the IoT market, different institutions such as the European Committee for Standardisation (CEN) in Europe and the Telecommunications Industry Association (TIA) in the United States have started to explore standardisation options. Effective collaboration among these standardisation bodies is needed to advance a universal IoT market, and in 2012, seven standardisation bodies from different countries created a harmonization group with this end in mind (Borgia, 2014).

According to Kevin Ashton, who first coined the term Internet of Things in 1999, the largest change created by IoT will come as computers become able to gather data and act on it without human intervention (Ashton, 2009). Currently, almost all of the data in the world have been created or recorded by humans. This is a significant bottleneck to understanding the physical world we live in, because humans have limited time and focus to capture information about the world. Computers and machines can operate around the clock, and by giving them the ability to see, hear and smell the world around them through sensors, we can begin the journey of tracking and counting everything that happens in the physical world. This will increase our understanding of the physical world, and the better we understand it, the closer we can get to an optimized world, where waste is minimized and production maximized.

The world is still far removed from having machines that can see, hear and smell the world as Ashton (2009) outlined in his vision. However, as the capability to track and manage physical objects and processes becomes widespread, decision making can become more data-driven, which in turn facilitates process and system optimization. Thus, IoT helps save time, money and natural resources while enhancing quality of life and enabling greater levels of effectiveness (McKinsey and Company, 2015; Porter and Heppelmann, 2015). Since artificial intelligence is also advancing rapidly, in the future decision making processes can increasingly be outsourced to intelligent objects, which have actuating capabilities (Urban, 2015). This leads to end-to-end process automation, lower costs and better productivity. In other words, while Ashton's (2009) vision is far away, we are moving towards it.

2.2. Business Models

A business model is the way in which a company "creates, delivers and captures value" (Osterwalder and Pigneur 2010) and the "blueprint of how a company does business" (Osterwalder et al. 2005). Thus, a business model describes what a company does (what kind of a product or service a company offers), how the company does it (manufacturers, delivers it, e.g. alone or with a partner), and how the company makes money (through e.g. licensing or selling products). The business model can also be used for uniting technological development and economic value creation (Chesbrough and Rosenbloom, 2002). Casadesus-Masanell and Ricart (2010) state that a business model is comprised of managerial choices and their consequences while Glova et al. (2014) assert that a business model can be seen in terms of a process model, which tracks the processes of a company. Moreover, Fleisch et al. (2015) see a business model as a set of four key components:

1. Who are the customers?
2. What is being sold?
3. How is it produced?
4. How is revenue earned?

As these perspectives illustrate, the business model of a company can be viewed in many different ways. However, many authors emphasize that the business model of a company can be broken down into components (Shafer et al. 2005; Osterwalder and Pigneur 2010; Muegge 2012). This component view is the most popular way of conceptualizing a business model, and it lies underneath the most prevalent business model framework: The business model canvas. Created by Osterwalder and Pigneur (2010), the business model canvas is a tool that can be used in creating a new business model or in analyzing an existing business model. It is based on a meta-analysis of business model frameworks (Dijkman et al., 2015), and while other business model frameworks also exist, most of them end up using the same building blocks partially (e.g. Fan and Zhou, 2011; Liu and Jia, 2010) or completely (e.g. Bucherer and Uckelmann, 2011; Sun et al. 2012). While the business model canvas is the most prevalent business model analysis and creation tool, some researchers state that a generally accepted view of what a business model should be comprised of is still missing (Morris et al. 2005; Schweizer, 2005).

The business model canvas has the following nine components:

1. Key partners - Who is the company partnering up with, and what is required of the partners?
2. Key activities - What activities are required to deliver the value propositions?
3. Key resources - What resources are needed to create value for the customer?
4. Value propositions - What value does the company deliver to its customers?
5. Customer relationships - What kinds of customer relationships does the company create and maintain?
6. Channels - How does the company reach its customers?
7. Customer segments - Who does the company create value for and target?
8. Cost structure - What are the costs of the business model?
9. Revenue streams - How is income generated from the customer segments?

These components are also referred to as building blocks. A business model is created by selecting one or several elements called types for every building block (Dijkman et al. 2015). For example, the building block value propositions can include the types of convenience, low cost, comfort, security or anything else, which is valuable to the customer.

The creation of a business model follows a sequential design process, which has the steps of mobilize, understand, design, implement and manage (Osterwalder and Pigneur, 2010). During the mobilize phase, the person responsible for the design of the business model needs to identify and gather all the resources that are necessary for a successful business model project, and communicate its rationale to the relevant stakeholders. Here, the mobilizer should establish a shared language for designing and describing the business model with other individuals, who are engaged in the design process (Pisano et al. 2015; Osterwalder and Pigneur, 2010).

In the understand phase, the design team chooses the resources that are needed for creating the business model. Once this has been done, different business model prototypes are brainstormed, and the different options are assessed until the best one is found and implemented. This constitutes the design and implementation steps of the business model design process (Osterwalder and Pigneur, 2010). Finally, in the manage phase, the external environment is monitored in order to identify changes in customer or market conditions. If there are changes in the external environment that warrant action, the business model needs to be adjusted accordingly (Pisano et al. 2015). Indeed, Osterwalder (2012) states: “designing business models is a constant interaction between the nine building blocks of the Business Model Canvas, which you control, and the environment in which you are designing it”.

According to Westerlund et al. (2014), the problem with business model tools such as the business model canvas is that they show the parts of a business without explaining the flow between the parts. These authors state that the interactions that take place between the parts of a business model are important, and that the business model canvas fails to take them into consideration. However, other researchers (e.g. Arnold and Kiel, 2016a; Dijkman et al. 2015) show that there are interactions between the different building blocks of the business model canvas. For example, key partners support the value propositions, which in turn create value for customer segments (Arnold and Kiel, 2016a). Osterwalder and Pigneur (2010) do not comment on the flow between the different parts of the business model canvas themselves.

2.2.1. Business model development

As Osterwalder and Pigneur’s (2010) business model design process illustrates, a company’s business model is not static, but must instead adapt to changes in the environment (Osterwalder, 2012). The world of today is influenced by dynamic social, political and technological changes, and for this reason it is worthwhile to briefly explore business model development, i.e. the process through which business models can be changed to better respond to changing requirements in the market place.

Bucherer and Uckelmann (2011) see business model development as a bridge, which closes the gap between technological and economic innovation, and it can be approached radically or through incremental steps. Top management is typically used to the existing business model, and radical change is often seen as inconvenient, because managers need to give up their mental models and dominant logic to pursue it. For this reason, most companies prefer incremental business model development over radical business model development (Arnold and Kiel, 2016a).

The process of finding the right business model often involves testing and learning through trial and error (Magretta, 2002; Sosna et al. 2010; Teece, 2010). Pisano et al. (2015) studied business model development and discovered that most business model creation or development processes involve learning in order to find and improve the business model. For example, Osterwalder and Pigneur (2010) refer to business model development as an iterative process, Sosna et al. (2010) talk about a trial-and-error approach and Teece (2010) posits that business model creation requires a learning approach. Moreover, a business model should be considered in the context of its ecosystem of suppliers, customers and competitors, and how this ecosystem may develop (Sosna et al. 2010; Achtenhagen et al. 2013; Kijl et al. 2005). By evaluating the environment and experimenting with both different product iterations and business hypotheses, companies gain information about when it is appropriate to move resources from current business models into new ones (Pisano et al. 2015; Ries, 2011).

Pisano et al. (2015) posit that competition is moving away from industries and that business model development should focus on identifying trend patterns and developing business models in and for trend patterns. Furthermore, these authors posit that business models need to be able to identify opportunities for innovation, if they are to survive in dynamic environments. For this purpose, Pisano et al. (2015) have developed a framework called the BIC methodology (Business, Innovation, Customer Experience) to analyze the business model, innovation and customers of a given trend. To analyze these, the BIC methodology looks at business model cliché, epicentre of innovation and user experience, respectively.

Business model cliché analysis is a technique that can be used for distinguishing common patterns between similar business models. It explains how people inside and outside the industry or the business view the business model, and how it operates. This includes the beliefs that affect what is thought of as being possible, and how business can be done with the business model. Pisano et al. (2015) discovered three business cliché categories: the product cliché, the interaction cliché and the resource cliché, which means identifying clichés pertaining to the product, interaction between the company and its customer, and the resources the company employs.

The epicentre of innovation looks at what building block(s) in the business model create innovation. Innovation can come from any of the blocks in the business model, and Pisano et al. (2015) identified three epicenters: Infrastructure, customer, and finance driven. For example, the infrastructure-driven epicentre includes all the blocks on the left side of the business model canvas: key activities, key partners and key resources, and innovation can come about e.g. through new kinds of key activities such as 3D printing (Pisano et al. 2015).

User experience refers to the subjective perception and experience, which a customer has while using and owning the product or service. It relates to emotional and experiential aspects of the product or service, as well as perception of usefulness and ease of use. User experience is also dynamic, and can change, if the customer has new experiences using the product or service. It is very important, because the experience a customer has using a given product or service has a significant impact on whether the customer will continue using the product or switch to another, competing product (Meyer and Schwager, 2007). For this reason, user experience should be kept in mind when value propositions, distribution channels, customer relations and revenue streams are designed (Pisano et al. 2015).

The BIC methodology can be used to analyze companies that operate within a given trend or industry to get a better idea of what kind of business models there are within a trend or an industry. Pisano et al. (2015) also recognize the business model canvas and its nine building blocks, and use them in a mutually supporting way with the BIC methodology. By analyzing different companies with both frameworks, entrepreneurs gain more knowledge on what trends and similarities there are within the business trend they are considering entering. The BIC framework is therefore a useful tool that can be taken into consideration in the business model development process.

2.3. IoT Business Models

As was discussed previously, IoT presents a wealth of business opportunities, and has many different applications areas (McKinsey and Company, 2015; Markman, 2015; Borgia, 2014). Given the magnitude of the IoT opportunity, IoT business models are currently underrepresented in academic literature (Gubbi et al. 2013). Furthermore, Mishra et al. (2016) and Dijkman et al (2015) assert that there is a lack of research on how business models can be created for IoT applications, and whether there is a difference between creating business models for IoT applications and normal products and services. Borgia (2014) states that conventional business models cannot be directly applied to an IoT context, but that new ones should be conceived. Despite the current lack of clarity on how successful business models are created for the IoT, it is believed that new business models will emerge, similarly to when the internet first surfaced (Bucherer and Uckelmann, 2011).

Mckinsey and Company (2015) posit that it is more beneficial to look at business settings than vertical businesses in IoT business model creation. Examples of business settings include smart cities, vehicles, home, human and factories. Within these settings, business-to-business applications are potentially more valuable than business-to-consumer applications. McKinsey and Company (2015) estimate that business-to-business applications can generate more value than consumer applications, and that business-to-business applications are potentially responsible for 70 percent of the value engendered by IoT.

McKinsey and Company (2015) also assert that creating a business model is complicated for the suppliers of IoT technologies. Since this market is still in its infancy, it is unclear how competitive advantage and successful business models are created. Given the lack of standardisation, competitive advantage could come from differentiable technology, differentiable data, software platforms, and the ability to provide complete solutions. In terms of technology, software and data competencies such as data storage, analytics and aggregation are expected to increase in importance over time (Bucherer and Uckelmann, 2011; McKinsey and Company, 2015).

The development of the IoT market could follow that of other technology markets such as personal computers and the internet, and occur in three phases: In the first phase, the foundation of the infrastructure such as microprocessors or operating systems in personal computers is created by the “arms suppliers.” In the second phase, applications such as online search in the internet are created by companies. Finally, in the third phase, adjoining businesses such as e-commerce on the internet are built (McKinsey and Company, 2015).

The ability to track the performance of devices gives companies the ability to sell their products as services, and monetize their merchandise through pay-per-usage or licensing value capture models (Gonçalves and Dobbelaere, 2010; Kortuem et al. 2010). However, these business models are not necessarily more profitable than the traditional ones, where the ownership of the product is transferred to the customer (Porter and Heppelmann, 2014). In order to work, a product-as-a-service (PaaS) business model needs to accurately measure how much the product is used. For example, when Xerox changed from selling copy machines to capturing value by the document, it started adding sensors to the relevant parts of the machine. This enables accurate billing based on usage and eases the selling of paper and toner (Porter and Heppelmann, 2015).

The ability to track the status of devices also gives companies the option of developing deeper relationships with customers through e.g. combining maintenance and software updates into the deal with the customer. This combination can create business insights, and a close relationship that is challenging for competitors to fracture (McKinsey and Company, 2015). For example, by gathering and analyzing data from hundreds of engine sensors, General Electric enabled its customer Alitalia to make changes to its flight procedures, which resulted in decreased fuel usage. These kinds of business insights then help GE to develop tight relationships with different airlines, and differentiate itself from its competitors (Porter and Heppelmann, 2014). However, the participation of the customers is needed to make these kinds of business relationships possible (Arnold and Kiel, 2016a).

Monitoring the usage and status of objects also has other commercial applications (McKinsey and Company, 2015). For example, car rental services can provide their customers with additional information regarding the carbon footprint of the vehicle, and charge their customers for the usage of vehicles or on lifecycle consumed. Similarly, washing machine manufacturers can charge their customers per washed load instead of charging for the ownership of the entire machine. These business models enable the company to retain ownership of the product, and gather large amounts of data on the performance of their products (Porter and Heppelmann, 2014). Gathering and analyzing data on the usage and performance of thousands or even millions of devices then enables companies to increase their expertise and understanding of their businesses and products (Porter and Heppelmann, 2015).

The ability to monitor devices also has ramifications for market segmentation, because usage patterns can be tracked by customer type. Thus, companies can create customized products for individual customers, which improves differentiation from competitors (Porter and Heppelmann, 2014). Over time, people may also become willing to pay for information, even though it is currently viewed as a part of the service or the product (Glova et al., 2014). Thus, IoT creates new opportunities for value creation and capture. (Bucherer and Uckelmann, 2011).

Bucherer and Uckelmann (2011) describe different IoT business model scenarios as examples of the kinds of business models that are enabled by IoT. The first one is product as a service (PaaS), and it means that instead of selling ownership of products, customers can use the product as much as they need, and only pay for the usage. For example, Hilti has shifted from selling professional power tools to offering them to their customers on a contract basis for a monthly fee. The advantages this gives to the customer include adjustable inventories, having the most current version of needed tools available, and smaller initial payment (Johnson et al. 2008). Meanwhile, Hilti benefits from a having a steady revenue stream that is easy to forecast and report. A more advanced version of PaaS is charging the customer on the basis of service performance. Examples of this include Power by the Hour and Performance Based Logistics (Kim et al. 2007).

The second business model scenario involves information service providers (ISPs). ISPs are companies, which have traditionally provided information pertaining to e.g. financial and marketing data, business news or political and social trends (Maglitta, 1990). However, over time, ISPs have broadened their service offering to data processing, as well as electronic information and professional computing services (Tallarico, 1998; Tang et al. 1999). ISPs have also taken on the role of information intermediaries (Bakos, 1990; Sarkar et al. 1995; Tang et al. 2001), and have the opportunity of acting as facilitators in improving the flow of information in IoT settings. Even companies that are not ISPs may consider creating additional revenue streams by selling data about products and their usage. However, the reaction of customer segments needs to be considered, as some customers might resent the monetization of their usage data (Porter and Heppelmann, 2014).

The IoT also enables ISPs to benefit from the potential revolution in market research, which comes from being able to collect vast quantities of data at a low cost, and analyze them in real-time (Bucherer and Uckelmann, 2011). This is a potential solution to e.g. the purchase of counterfeited goods, which is a difficult problem, because it is expensive to track and identify products across the globe. IoT lowers this cost and enables the sharing of product-related information. Consumers can then use this information to verify that the product is what it’s supposed to be and avoid counterfeits (Bucherer and Uckelmann, 2011).

Scenario three is end-user involvement. IoT can be used for connecting all customers across the life cycle of a product, which engenders new ways of integrating consumers to co-creation processes. While co-creation schemes do already exist in the form of e.g. product reviews, IoT enables more direct linkage between a specific product and the information related to it. Companies can incentivize customers to provide information about the purchased product, which enables the companies to learn more about customers' preferences as well. The customers can also be charged for the gathered information either directly or indirectly (Bucherer and Uckelmann, 2011).

Scenario four involves right-time business analysis and decision making. Currently, there is not a great deal of real time business analysis or decision making beyond internal processes and two-way business relationships. However, IoT enables the possibility of real time accessibility and analysis of data over different supply-chains and product lifecycles. For example, an intelligent truck can track the condition of perishable goods within its container, communicate this information and receive responses in real time, so that the route of the truck can be altered if necessary (Bucherer and Uckelmann, 2011).

As these scenarios show, information is a major source of value in the IoT (Bucherer and Uckelmann, 2011), and it can even become the value proposition (Glova et al. 2014). IoT analytics (2015) even state that there are going to be entire industries, which create business models on the basis of information generated through IoT. Since information and data are a key part of IoT, it is worthwhile to explore information in greater detail. The lowest common denominator of information is data, which refers to information in raw and unorganized form i.e. letters, numbers or symbols (Business Dictionary, 2017). Information in IoT is derived from data, which is collected from different devices, buildings and other connected objects. In IoT business models, the connected devices are the most important source of data, and this data can be enriched by the data that organizations already possess (Gartner 2014; Oracle, 2016).

Data security and data management are indispensable, if organizations are to benefit from IoT, and the importance of data as an asset should be emphasized within the organization (Arnold and Kiel, 2016a). This can be challenging, because information is difficult to quantify, and it is usually not recognized on the balance sheet as an individual entity. Other key factors of benefiting from data include strategic partner networks, and the importance of customers as collaborative key partners (Bucherer and Uckelmann, 2011). Arnold and Kiel's (2016b) research on the impact that IoT has on the business models of established manufacturers yielded similar findings as data analysis and collaboration with the customer were found to be important requirements for benefiting from data.

IoT enables the collection and analysis of detailed information that pertains to the usage, status and location of objects, products, and different product versions (Bandyopadhyay and Jaydip, 2011). This information can be exchanged directly or indirectly between information providers, companies and end customers. The flow of information between these three parties can be uni-, bi- or multidirectional, but the consent of the other parties is required if bi- or multidirectional information flows are to be used. Customers may be reluctant to send data to companies, and this has been a challenge for some IoT consumer applications such as smart refrigerators (Bucherer and Uckelmann, 2011; Mishra et al. 2016).

Moreover, the information distribution channels require different interfaces than what are typically used in B2B and B2C scenarios (Bucherer and Uckelmann, 2011). The desktop and touchscreen interfaces, which currently account for the majority of interfaces cannot be utilized by all IoT devices, because they are often too small, inconspicuous and remotely controlled (Gärdenfors, 2015). However, companies are taking heed of the need for IoT interfaces, and different solutions have already emerged (Gärdenfors, 2015; Talbot, 2014). Finally, while the exploitation and management of information and information flows has its challenges, the emergence of new, more detailed information will enable new forms of value creation and capture as was already discussed (Bucherer and Uckelmann; McKinsey and Company, 2015).

In addition to information, business transactions are characterized by a physical product, and money flow. In the IoT, there is always an information link to a physical product, which includes the information about the physical product as well as information made possible by the IoT. Since IoT links information with things, it provides business opportunities for 3rd party data aggregators and information service providers, as was mentioned before (Bucherer and Uckelmann, 2011).

The IoT is still very unstandardised and interoperability issues are pervasive, which makes it challenging to design business models for the IoT. With a wide array of dissimilar objects ranging from toothbrushes and microwaves to cars and industrial machinery, it is difficult to standardize the interfaces through which all of these objects can connect to the internet (Westerlund et al., 2014). However, business opportunities abound as interoperability improves, the number of objects connected to the internet increases, IoT infrastructure becomes more established and the standards become more entrenched (Gubbi, 2013). In the meantime, the aforementioned issues make it possible for hardware, software and service providers to provide customized turnkey solutions to meet the specific needs of individual customers (McKinsey and Company, 2015). Ultimately, the number of possible business models within the IoT rises with the number of interconnected devices, and as this number increases, the possibilities are virtually limitless (Leminen et al. 2012).

2.4. The Network Perspective

Many researchers state that business models, and especially IoT business models, function as networks and ecosystems (e.g. Westerlund et al. 2014; Glova et al. 2014; Pisano et al., 2015; Andersson and Mattsson, 2015). A business ecosystem is a body of economic actors aided by a bedrock of interacting organizations and individuals (Moore, 1996). Westerlund et al. (2014), and Arnold and Kiel (2016a) also consider customers, competitors and other stakeholders as parts of a business ecosystem. Pisano et al. (2015) agree, and also state that partners in an ecosystem do not have stable roles anymore. Thus, we can see that business ecosystems are complex and have different kinds of actors.

The core of business ecosystems is the technological platform (Cusumano and Gawer, 2002), which can be defined as a body of technological building blocks and auxiliary elements that enterprises and customers can utilize and consume to create supplementary products, technologies, and services (Muegge, 2011). The IoT forms the technological platform of IoT business ecosystems, and from a technical perspective, an IoT ecosystem is comprised of the connections between objects and the internet, as well as the associated software and hardware platforms and the standards, which enable the connections between these elements (Mazhelis et al. 2012). The entirety of an IoT business ecosystem thus consists of the IoT ecosystem and the aforementioned stakeholders, and is highly networked in nature (Westerlund et al. 2014).

The complexity of an ecosystem correlates with the number of players in the network (Möller et al. 2005), and the IoT is currently very chaotic because it is unstructured, unstandardized, and open for new members. The chaoticness of IoT is exacerbated by the lack of clarity on who or what kind of companies will be the key players in the IoT ecosystem (Westerlund et al., 2014). For example, McKinsey and Company (2015) estimate that the importance of software and analytics will increase over time, but will the key role in software development be held by IT companies, user-generated communities or some other party?

While all of the aforementioned stakeholders and technical elements are important in an IoT business ecosystem, it is partnerships between the companies that produce the product or service that are most responsible for value creation. Furthermore, research shows that the partner structure of an IoT business model is more complex than the partner structure of traditional business models (Dijkman et al., 2015; Hui, 2014). However, Dijkman et al.'s (2015) research indicates that partnerships are increasing in importance and that co-operation results in long-term partnerships, information sharing and reduced costs. Hence, IoT business ecosystems should be designed so that they maintain the partners' and other stakeholders' desire to remain in the ecosystem. This means that participation should be beneficial for all parties.

IoT business models are currently facing challenges posed by e.g. standardization issues, the immaturity of the IoT market, and unstructured business ecosystems (Borgia, 2014; Weber, 2010). The first two challenges have been talked about in previous paragraphs, and the last one means that there is a lack of business ecosystems, for which IoT business models can be developed. For example, the internet has many business ecosystems from Amazon Web Services to the Google's AdSense platform, but IoT currently lacks these business ecosystems, and the key players that run them (Westerlund, 2014).

In order to address this challenge, and create business models that are beneficial for all of the parties within the ecosystem, Westerlund et al. (2014) espouse a shift from thinking about the business model of a company to focusing on ecosystem business models instead. An ecosystem business model is concerned with creating and capturing value not only for the individual company, but for the ecosystem as well. Moreover, Westerlund et al. (2014) posit that managers will be more effective in designing IoT business models, if they use business model design tools that take the ecosystemic nature of IoT into consideration. Current business model frameworks are good for designing business models for individual organizations, but are not as applicable to examining and creating business models for groups of companies operating in interdependent networks (Weiller and Neely, 2013).

The key in designing an ecosystem business model such as an IoT business model lies in creating the business model so that all parties gain value from it. Frameworks that embrace this perspective have already been created, e.g. by Allee (2000) and Gordijn and Akkerman (2001). Westerlund et al.'s (2014) ecosystem business model framework starts with understanding that value creation and capture are the foundation of all business models. These authors argue that successful IoT business models can be created by considering and working with different facets of these two essential business model elements. These different facets are value drivers, value nodes, value exchanges and value extracts.

Value drivers are the motivations, which individual companies as well as the network as a whole have to satisfy a need in order to create and capture value. Examples of value drivers include sustainability and improved customer service. Furthermore, value nodes are different elements within the ecosystem that work and link together to create value. Value nodes include the physical elements of the IoT ecosystem such as sensors, as well as single activities, processes, people, or even groups of organizations (Westerlund et al. 2014). The value nodes basically include all of the elements within the ecosystem as well as the connections between them.

Value exchanges happen between and within different value nodes, and they explain how value flows within the ecosystem. The value exchanges display how the ecosystem works, because they depict how different resources such as money, knowledge and information flow between the different players. This is very important, because it also shows how earnings are created and shared in the ecosystem. Finally, the value extract focuses on the portion of the ecosystem, which extracts value. In other words, it delineates the value that can be monetized, and the associated value nodes and exchanges, which are needed for value creation and capture. Value extract is useful for honing in on the commercial aspect of the ecosystem, which is also the most meaningful part of it (Westerlund et al. 2014).

Westerlund et al. (2014) conclude their discussion of ecosystem business models by talking about value design, which is the aggregation of the aforementioned facets. It is the top-level architecture, which explains how value creation and capture are designed into the ecosystem. Finally, these authors posit that because value design can be applied at the ecosystem level, it is more fitting to the ecosystem context than the term business model.

Thus, Westerlund et al. (2014) posit that when we are talking about IoT and ecosystem business models, we should be talking about value design instead.

2.5. Internet of Things Platforms

The empirical section of this thesis examines the business models of IoT platforms, so it is pertinent to explore IoT platforms in detail. By IoT platforms, the author is referring to IoT application enablement platforms, but the term “IoT platform” is used for the sake of brevity. It also critical to note that the IoT platforms discussed here should not be thought of as multi-sided platforms. The difference between the two is that multi-sided platforms connect different customer or participants groups, whereas IoT platforms connect the devices on one side, to the applications and enterprise IT systems on the other side. So while a multi-sided platform like Facebook connects users and companies, an IoT platform like Thingworx connects devices to the applications and IT systems the platform connects to. The other capabilities of IoT platforms are delineated below.

While some IoT platforms have been in existence for over a decade, the IoT platform market only emerged four years ago (IoT analytics, 2015). The role of the IoT platform is to enable different IoT devices to connect to each other, and to different IoT applications. The applications in this context refer to e.g. visualization and reporting tools as well as the user interfaces used to control and manage the devices (Kaa Project, 2016). IoT platforms connect the data network, which yields access to the applications, to the sensors that are attached to the devices (Singh, 2016). Most IoT platforms are hosted in the cloud, but there are also IoT platforms, which are hosted on site.

IoT platforms have evolved from traditional machine-to-machine (M2M) platforms, which have been in existence for several decades (Morrish, 2013). In contrast to the M2M platforms, which were developed as standalone or “stove pipe” solutions for single processes, IoT platforms are designed to integrate more horizontally to a variety of data sources and other applications. Thus, the IoT platform can be seen as the glue between application developers, connected devices, and other company IT systems (Valkonen, 2014). It can be considered as the middleware of the entire IoT environment that exists between the technology and application levels (Bandyopadhyay et al. 2011; Balamuralidhar et al. 2013).

The IoT platform market has only emerged in the recent years, and with over 300 players, it is complex and dynamic. However, IoT platforms are crucial for creating scalable IoT applications, which connect things, systems and individuals, and they are necessary for almost any IoT business case (Scully, 2016b). For this reason, the platform infrastructure is expected to grow alongside the number of connected devices, and the value of the IoT platform market is estimated to reach $1 billion by 2019 (IoT analytics, 2015; Scully, 2016a).

IoT platforms have several different functions and tasks, which can be separated into eight components (Scully, 2016b). The first one is connectivity and normalization, which refers to the platform's ability to obtain data from different devices, in different protocols and in different data formats. The platform also needs to normalize the data i.e. to put it into one software interface, because the data needs to be in a single format before it can be analyzed. This is accomplished through application programming interfaces (APIs) or software agents (IoT analytics, 2015).

The second component of an IoT platform is device management. This part of the platform is responsible for making sure that the connected devices are working as intended and their software are up to date (Bandyopadhyay et al. 2011). This component also ensures remote access and control, which is crucial for managing thousands or millions of devices efficiently (Balamuralidhar et al. 2013).

The third component is the database of the platform. It needs to allow for vast quantities of both structured and unstructured data to be stored on the platform (Bandyopadhyay, 2011). Some IoT solutions also require real-time analysis of data and instantaneous decision making, and the database needs to allow for this as well (IoT analytics, 2015).

The fourth component is processing and action management. It refers to the rule based if-this-then-that settings, which utilize the data collected by the sensors to make decisions and take action. For example, a smart home solution can be configured so that all the lights in the house are turned off when the sensors in the house detect that the GPS signal coming from the owner's smartphone is more than five yards away (IoT analytics, 2015). Given the difference that exists between IoT devices, different rules and rule monitoring techniques are needed for different devices (Bandyopadhyay, 2011).

The fifth component is analytics, which means the data mining, machine learning and pattern detection techniques that are used to obtain the maximum amount of value from large data sets (Scully, 2016b). Since analytics is contextual, the analytical algorithms are usually specifically created for the applications in which they are used. For this reason, the IoT platform needs to understand different scripting languages, such as Python and R that are used to create the algorithms (Balamuralidhar et al. 2013).

The sixth component of an IoT platform is visualization. The platform needs to have tools and APIs for creating visualisations such as pie and bar charts of both raw sensor data and processed, analyzed data (Balamuralidhar et al. 2013). Creating these visualizations then allows one to see patterns, trends and outliers in the data.

The seventh component is additional tools. Some IoT platforms give the developer and the manager of the IoT solution supplementary tools that can be utilized in managing the platform. Examples of additional tools include editors, which allow one to visualize and control connected devices through smartphone apps as well as access management tools, which enable one to decide different levels of accessibility of devices and data for different individuals in the organization (Morrish, 2013; IoT analytics, 2015). Regardless of how many additional tools are provided, the platform needs to take the requirements of software developers into consideration and provide an easy-to-use development environment within the platform (Balamuralidhar et al. 2013).

Finally, the eighth component, external interfaces, refers to the APIs, software development kits (SDKs) and gateways that enable the platform to access external data and to integrate with other IT systems such as ERP, CRM and manufacturing execution systems (Porter and Heppelmann, 2014). It is very important that the IoT platform can be integrated with existing enterprise IT systems, and well-functioning interfaces can reduce integration times from months to a matter of days (IoT analytics, 2015).

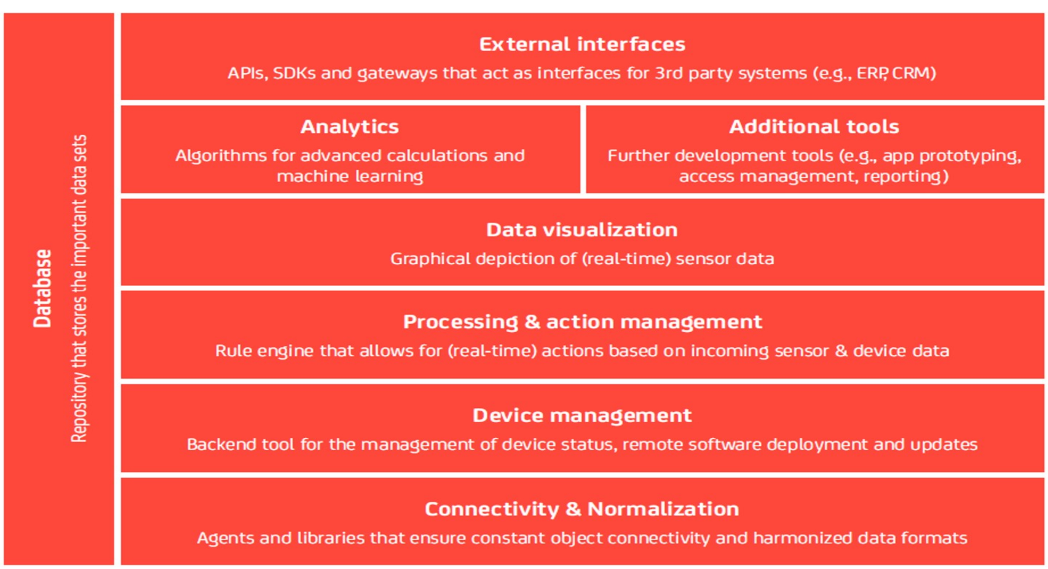

Figure 3: The eight components of an IoT platform (IoT Analytics, 2015).

Most of the existing IoT platforms do not provide all of these components, and may focus only on cloud storage, data security, CRM software or connectivity management (IoT analytics, 2015). Indeed, the platforms differ from each other in terms of technological depth, segment focus and the implementation/customization approach. In terms of technological depth, the platform can be either a simple connectivity platform, which only enables data collection, normalization and messaging or an action platform, which also makes it possible to have rule-based action management (Morrish, 2013). Still more technologically advanced platforms are called full-scale platforms. These platforms work with a number of protocols and standards, scale up to accommodate large numbers of devices and data, and allow for a seamless integration of external interfaces (IoT analytics, 2015).

There are also some differences between the segments the platforms are geared for. Since creating IoT solutions for different verticals such as smart homes, smart cities or agriculture have different requirements, IoT platform companies often choose to only focus on a handful of vertical customer segments. The different requirements pertain to the different needs in protocol and device support, interoperability with different external interfaces and different kinds of security infrastructure (IoT analytics, 2015).

Finally, IoT platforms are different in terms of how they are integrated with the devices they are connected to. Some companies offer a “one-stop-shop” platform, which has a limited variety of things that can be integrated into the platform (Morrish, 2013). Furthermore, these kinds of platforms have very specific developer tools and limited technical support. Conversely, companies, which offer customizable IoT platforms provide comprehensive implementation support, and are focused on platform integration on a case-by-case basis. The one-stop-shop platforms are more common in B2C scenarios while customizable platforms are prevalent in B2B situations (IoT analytics, 2015).

In addition to the aforementioned eight components, there are several features, which an IoT platform should have. First, an IoT platform needs to have an identity management system so that different devices, applications and companies can be present on the platform at the same time (Morrish, 2013). This ability of the platform to host multiple companies is referred to as multi-tenancy. The key aspect of multi-tenancy is that the data and resources of the tenants are secure and can’t be accessed by the other tenants (Balamuralidhar et al. 2013).

As was discussed before, one of the key challenges of IoT is interoperability. IoT platforms have an important role joining the different IoT elements and technologies together as well as enabling interoperability between different hardware and software standards (Bandyopadhyay et al. 2013; Valkonen, 2014). This is done through APIs, which enable communications between the physical and software layers of IoT. Beyond the interoperability of these different IoT elements, the IoT platforms themselves need to be interoperable, if IoT is to work in enterprise data centers (Botelho, 2013). This calls for standard APIs that different companies and devices can connect to.

IoT platforms also play a critical role in the security of IoT (Morrish, 2013).The devices themselves can rarely support modern security hardware or software, because they have limited processing power (Porter and Heppelmann, 2015). However, in IoT, every connected object can be a point of network access and a launching point of a cyberattack. Thus, the security and encryption need to come from the platform. In terms of security, the IoT platform should also provide device authentication, integrity service and access control (Bandyopadhyay et al. 2013).

IoT platforms also need to be scalable, so that they can handle large and fluctuating numbers of users, data and processable events. (Morrish, 2013). Ideally, IoT platforms enable tenants to scale and update all the common services such as data storage and analysis services as well as the tenant specific services on their own. Both of these services can use auto-scaling systems and load balancer solutions to reach the best result. These systems and solutions monitor the load on the servers, and tap into the necessary resources using infrastructure cloud services. This enables the load to be balanced between the obtainable resources (Balamuralidhar et al. 2013).

3 Methodology

For the empirical part of this thesis, I have chosen to study business models that have been created around IoT platforms. The main purpose of my study was to learn more about, and explore the business models of different IoT platform companies. Specifically, I wanted to see what kind of patterns and differences could be identified, and to my knowledge, this kind of a study has not been done before. Moreover, studying all kinds of IoT business models is beyond the scope of a master's thesis, which is the reason I chose to narrow my focus to just one type of company. Since the IoT platform market has only existed for four years (IoT analytics, 2015), and my purpose was to explore this new area, it is appropriate to conduct qualitative instead of quantitative research. Malterud (2001) states that qualitative research is the preferred research method in exploratory research in social research areas such as business. Qualitative research is also useful in gaining understanding and insights about unexplored subject areas (Ghauri and Gronhaug, 2005). Finally, the goal of understanding a previously unexplored subject reflects the research objective, which was centered on understanding how business models can be developed for IoT applications.

I identified the first companies to be contacted by reading Valkonen's (2014) study, and complemented my contact list by looking for different IoT platforms on the internet using Google search. I approached 40 IoT platform companies, and conducted twelve semi-structured interviews in total. Semi-structured interviews utilize pre-identified themes in a consistent way so that the researcher can learn more about the subject at hand, while at the same time leaving room for additional, more detailed questions and their respective responses (Qu and Dumay, 2011). Moreover, semi-structured interviews are useful in guiding the discussion towards the subjects that the interviewer wants to explore, and they are usually the most effective and convenient way to gather information (Brinkmann and Kvale, 2009). For these reasons, I deemed that semi-structured interviews would be a good qualitative research method for my thesis. Furthermore, I wanted to compare my results with those of Dijkman et al. (2015), who used this research method as well.

Dijkman et al. (2015) studied how business models can be created for generic IoT applications by studying literature and conducting eleven semi-structured interviews with companies that create and sell IoT products or services. In this context, the word generic means "in general", and thus, is referring to any kinds of IoT applications. This research method was used to discover the building blocks and types that are relevant in IoT business models, and the interview questions were based on a questionnaire from Osterwalder and Pigneur's (2010) book. Furthermore, their study looked at the types within the building blocks to determine what kind of types are used in IoT business models, and which types within different building blocks are the most important. In my study, I have looked at these same phenomena, and compared my results with those of Dijkman et al. (2015). I chose Dijkman et al.'s (2015) study as the point of comparison, because I wanted to compare the business models of IoT platforms with those of generic IoT applications, and comparing my findings with those of Dijkman et al. (2015) provided an opportunity to do so. Furthermore, Dijkman et al. (2015) called for repeating their study in a different setting, and I was able to find this in the context of IoT platforms, as well as in a multi-cultural set of interviewees.

In addition to the interviews, Dijkman et al. (2015) also conducted a survey to discover the relative importance of the building blocks and types that were identified during the interviews. This survey utilized a five-point Likert scale that ranged from "strongly disagree" to "strongly agree" to determine whether the surveyed IoT professionals agreed on the importance of a given building block or type. However, I was informed that doing both interviews and a survey is beyond the scope of a master's thesis, so I only conducted interviews. In comparing the results of my interviews to those of Dijkman et al. (2015), insights into whether the business models of IoT platforms differ from those of generic IoT applications were gained. In order to maximize comparability between the two studies, I have used the same interview questions as Dijkman et al. (2015). These interview questions are based on the business model canvas developed by Osterwalder and Pigneur (2010), which is the analytical framework used in this thesis.

Dijkman et al.'s (2015) study focused mainly on American and Dutch respondents, and the authors recognized that there is need for further studies to validate their findings. While the scope of my thesis is limited, my goal was to meet this need to the extent that my thesis allowed. In addition to two American companies, I conducted and used nine other interviews with IoT platform companies from a total of eight different countries. The countries in question included Colombia, Finland, Germany, Italy, Korea, Russia and the UK. One of the twelve interviewed companies provided a mobility-as-a-service platform instead of an IoT platform. For this reason, I disregarded this interview and focused on those I conducted with IoT platform companies. Furthermore, three of the companies preferred to stay anonymous, and one of these, Company A, didn't answer all of my questions, so their responses are incomplete and used as such. Once the interviews were done, they were transcribed and coded.

The interviewees and their respective companies are listed below:

- Mark Benson, CTO, Exosite - An American company with around 150 employees
- Agustin Pelaez, CEO / Co-founder, Ubidots - A Colombian IoT platform start-up employing ten people
- Benoit Delalande, Senior Manager - IoT Strategy and Business Development, Samsung - A very large South Korean company, which employs almost 500 000 people
- Company A - An IoT platform start-up focusing mostly on the utilities and manufacturing segments
- Company B - A fairly large company offering IoT modules and a platform to a variety of segments
- Jari Salminen, Managing Director - Sales & Partners, Cumulocity - A German IoT platform company employing 50 people
- Company C - A Finnish software and IoT company employing around 300 people
- Pasi Hurri, President and CEO, BaseN - A Finnish IoT platform company employing around twenty people
- Sami-Pekka Salminen, Head of Industrial Internet, Oracle Finland - An American software giant employing around 136 000 people
- Tara MacLachlan, IoT Business Manager, Eurotech - An Italian company, which employs around 380 people
- Victor Polyakov, CEO and Product Director, Tibbo Systems - A Taiwanese-Russian company providing software, and IoT solutions

The findings of my study will be presented next. I have chosen to present these findings thematically, which means that the findings are discussed under the nine building blocks of the business model canvas. This not only enabled me to compare each business model component by company, but also to compare my findings with those of Dijkman et al. (2015), one component at a time.

4 Findings

This thesis had two research questions: Which business model building blocks and types are the most important when developing business models for IoT platforms, and how are the business models of IoT platforms different from those of generic IoT applications? This section presents the findings that were obtained during the interviews, which in turn provide the information necessary for answering these research questions. Furthermore, I have presented an overview of the findings of Dijkman et al. (2015) in figure four, and an overview of my findings in figure five, which is followed by a summary of the main findings. This summary is followed by the discussion chapter, which also reviews the theoretical implications of the findings.

4.1. Customer Segments

The interviewed companies have customers from a wide variety of segments that range from vehicle telematics and healthcare to smart homes and agriculture. While IoT Analytics (2015) state that IoT platforms focus only on a handful of customer segments, four of the eleven interviewed platform companies stated that they focus on more than four customer segments. Oracle and Company B even described their platform as being generic in the sense that they don't care what the vertical market or the use cases are. Indeed, the representative from Company B stated that:

"We can track your car, we can track a water station, a mill, a farm, cause at the end of the day, it's about talking to a machine or a thing, translating the data or normalizing the data as we like to say, and getting the data delivered somewhere for consumption and analysis."

All of the interviewed companies only have business-to-business (B2B) customer segments, with the exception of Ubidots, which also serves customers in the business-to-consumer (B2C) area. Their customers in this segment include students, researchers and education initiatives.

Industry is the most common customer segment with nine of the interviewed companies stating that they serve industrial customers. Seven respondents also said that industry is one of the most important customer segments, if not the most important. Within industry, the interviewed companies have customers from many different fields, including smart industrial products, oil and gas, industrial manufacturing, industrial machines as well as energy and power plants. Other frequently mentioned customer segments include health care, vehicle telematics and logistics, as well as smart home, with five, four and three respondents serving these customer segments respectively. Finally, two of my respondents have customers in the agriculture sector.

Dijkman et al.'s (2015) research yielded five customer segments, which are, in the order of importance: Multi-sided platforms, mass market, diversified, niche market and segmented. As we can see, there is no overlap between these findings and those of my research, which indicates that the business models of IoT platforms are different from those of generic IoT applications as far as customer segments are concerned. My respondents mentioned that they have different verticals as their customer segments, whereas Dijkman et al. (2015) talk about customer segments such as multi-sided platforms and mass market. The only one of Dijkman et al.'s (2015) discovered types that resembles my findings is diversified, as my respondents also had several customers segments. Apart from this, the only similarity between the findings of my study and Dijkman et al.'s study is that both show a number of types in this building block instead of just one or two.

4.2. Value Propositions

The key part of any business model is how it creates value for the customer, and the interviewed IoT platform companies accomplish this in a number of ways. The most important of these are enabling the customer to reduce operational expenses, create new revenue streams, and more easily comply with regulatory requirements. The reduction of operational expenses comes from being able to monitor connected devices such as machines, oil rigs and platforms remotely, and to proactively respond before the device malfunctions. This means that the customer can send a mechanic on site before the machine breaks down, and prevent the down time that would otherwise occur. Ideally, the device has the ability to heal itself through software updates, and the mechanic never even has to visit the machine. The reduction of operational expenses is an integral type of value creation for an IoT platform, as all of the interviewed companies said that they create value this way.

The creation of new revenue streams is another common type of value creation for IoT platforms. The new revenue streams come from selling the data the assets are producing, or from offering new services in addition to the physical product. Seven of the interviewed companies stated that they create value for their customers by enabling them to create new revenue streams. The representative from Company B shared an illustrative example of how their IoT platform enables their customers to create new revenue streams:

"Then to make money what we're seeing is a lot of companies are instrumenting their machines, and I'll use an example of a company that makes industrial cleaning equipment. Think of it as over-sized vacuum cleaners that you see at airports, in hospitals and all that, these big cleaning machines. We work with the company that has IoT installed in every machine, where they can know where the location is, how it's operating, when it's being used. And it's a couple of things they can do with that.

They're selling a lot more aftermarket products now, because they know when the pads have to be replaced. When certain fluids are running low. And they can send these things in advance and sell maintenance contracts. Where in the past they would sell the machine to somebody and never know, hear about the machine ever again. Now they have a constant dialogue with their customer. They know exactly what the condition is of the machine. And they say hey no worries, we're not selling you machines, we're selling you cleaning. And we'll sell you the soaps, the new belts, the new pads. We'll send them to you in advance. Just pay the annual fee based on usage and you don't worry about anything else. We'll worry about the maintenance and the upkeep of the machine. So that's a new revenue stream there. And also a much closer customer relationship than they ever had before."

As this example shows, implementing service into the business seems to be conducive to creating a tight customer relationship, as was stated by McKinsey and Company (2015). Moreover, six of the interviewed companies stated that they create value by helping their customers deal with regulatory compliance. As explained by Mark Benson of Exosite:

"We have customers that are monitoring like cold chain refrigeration cases in supermarkets and grocery stores that store milk and yoghurt and cheese. And they have to monitor those and the temperature, and record that and in United States you have to report that to the Food and Drug Administration and make sure that it's safe food that's being sold in their stores. And the Internet of Things helps automate collecting those kind

of temperature measurements, and then equally reporting them to the FDA on regulatory compliance issues."

While Benson refers to FDA in the United States, the other interviewed companies told me about situations, where their customers use the IoT platform for regulatory compliance in South America and Europe as well, so it is a multinational phenomenon.

While the reduction of operational expenses, creating new revenue streams, and helping with regulatory compliance are the most common ways the interviewed companies create value for their customers, the interviews also revealed other ways of value creation. For example, Exosite creates value by enabling its customers to integrate machine data with enterprise IT systems, Company B provides convenience by enabling comprehensive PaaS solutions, and Ubidots provides security by allowing its customers to know if an asset is being stolen. Furthermore, Samsung's ARTIK Cloud platform shortens the time it takes to connect devices to IT backends from a couple of months to a couple of hours, and Tibbo is creating monitoring solutions that have a short time to market and a low price. Finally, Cumulocity and BaseN also look at value propositions from a more meta-level by saying that they "enable connected business by enabling the customer to collect, integrate and analyze the data", and "help companies understand their customers, which means collecting data from the customer and acting on it all the time."

Company B and Sami-Pekka Salminen from Oracle stated that one of the most significant sources of value their IoT platform creates comes from enabling their customers to change their business model into a PaaS model. According to Salminen, ultimately companies wish to become service companies, because they seek to obtain higher margins, and the representative from Company B said that paying for a comprehensive service is more convenient for the customer. Furthermore, moving to a PaaS model yields steady revenue streams over a period of time instead of large sums that are received at hard to predict intervals, which is better from a reporting perspective.

Dijkman et al.'s (2015) findings show a number of value propositions, the most important of which are convenience / usability, "getting the job done", performance, possibility for updates and comfort. As with the customer segments building block, there is little overlap between my findings and those of Dijkman et al. (2015): Company B was the only one of my respondents that mentioned convenience, and none of them talked about "getting the job done." They also didn't mention performance explicitly, but it is related to reduced operational expenses, better regulatory compliance, and some of the other types within my findings. However, none of my respondents mentioned neither comfort nor possibility for updates, which are significant types within this building block according to Dijkman et al.'s (2015) findings.

My findings also don't include accessibility, customization, design, price, newness, or brand/status, which are less important types within this building block according to Dijkman et al.'s findings. However, Dijkman et al.'s (2015) results also show that cost reduction and risk reduction are types within this building block, and these are related to reducing operational expenses and better regulatory compliance - types in this building block according to my findings. Thus, with the exception of reduced operational expenses, convenience, and to some extent, performance, there is little in common between the findings of the two studies as far as this building block is concerned.

4.3. Channels

The most important channel for the interviewed companies is the partner channel, as seven of the companies in the study said that they reach their customers through their partners. These partners can be hardware companies, such as sensor manufacturers, distributors or systems integrators, who sell the platform to the customer in addition to, or in conjunction with their own offering. Five of the companies, who use the partner channel said that it is also the channel that works the best.

In addition to the partner channel, direct sales are also used by seven of the interviewed companies. However, of these seven companies, only BaseN and Samsung said that this channel works the best. For the other five companies, which are Oracle, Company C, Cumulocity, Company B and Exosite, the direct sales channel is just one of the channels they are using. For all of these seven companies, the direct sales is mostly about targeting strategic accounts instead of calling different companies across the board.

Ubidots is the only one of the eleven interviewed companies that relies entirely on internet marketing and has no direct sales efforts. Samsung, Company B, Company C, Tibbo and Exosite also utilize the internet, but it is mostly used for marketing instead of sales. Conferences and trade shows are the marketing channels that are used the most, with seven respondents saying that they use these channels. Internet marketing is second with five mentions, and the other, less important marketing channels are industry publications, social media and webinars. Three of my respondents said that they use industry publications, while social media was mentioned twice and webinars were mentioned once.

Dijkman et al.’s (2015) research shows that web sales, partner stores, sales force, wholesaler and own stores are the types within the channels building block. Web sales is the most important type within this building block according to Dijkman et al.’s (2015) study, which is different from the results I had. While my interviewees use the internet channel, they use it mostly for marketing purposes. However, there are more similarities between the results of these two studies in this building block, than in the previous building blocks. Partner sales and direct sales force are present in the findings of both studies, and these are also the most important channels according to my results. However, my respondents do not use wholesalers or their own stores when selling their IoT platforms. Thus, the findings of the two studies are similar in that both include partner sales, direct sales and web sales, but the importance of these types is different between the two studies.

4.4. Customer Relationships

The customer relationships of the interviewed companies are very similar as all eleven companies described the customer relationship as tight, deep and consultative. This tight relationship occurs through frequent communication such as having daily calls calls, or by having a steering group that consists of both customer and focal company employees. The customer relationship is deep, because the customers of the studied companies are often implementing IoT for the first time, and “need a lot of hand-holding”, to bring the solution to life. Benoit Delalande from Samsung stated that IoT is not mature enough to have standardized solutions, which is in line with McKinsey and Company’s (2015) assertions. For the aforementioned reasons, the interviewed companies need to “design the path with customer” and act as consultants so that the optimal way to implement IoT can be reached. As Benson from Exosite explains:

“Even through today there's a lot of education that happen (sic)*, and we're just educating people. They often will ask about business model, how do we make money with IoT, how does it make sense not just-, how do you do it, but why should we do it and what is the business case for it?”*

Furthermore, Salminen from Oracle said that quite often the customers do not have a finished vision, so it helps that Oracle has the ability to consult and guide them. The customers also expect the relationship to be deep, because implementing IoT typically requires a radical business transformation. Victor Polyakov from Tibbo explained that especially the original equipment manufacturers (OEMs) expect the relationship to be deep, because switching to IoT means that their business will be completely dependent on the platform.

Dijkman et al.'s (2015) findings show that the most important types within the building block of customer relationships are communities and co-creation. These findings are very different from mine as my respondents did not mention these types even once. The deep, consultative customer relationships, which my respondents talked about can be thought of as co-creation, as the interviewed companies are often creating the solution with the customer. However, since they do not provide definitions for their types, it is uncertain whether this is the kind of co-creation Dijkman et al. (2015) are talking about. Self-service and automated service, which are types within this building block according to their findings, are the opposite of a deep, consultative customer relationship. However, Dijkman et al.'s (2015) findings in this building block also include personal assistance and dedicated assistance, which are in line with my findings. Hence, Dijkman et al.'s (2015) findings suggest a range of different kinds of customer relationships, whereas my findings show only deep and consultative customer relationships.

4.5. Revenue Streams

The interviewed companies have a variety of revenue streams, but the most important one is charging customers based on the number of devices that they connect to the platform. In this revenue model, the customers pay per device as these are connected to the platform, and are charged for this as often as the contract determines. Seven respondents use this type of revenue stream, and monthly payments are the most common payment option with five respondents using only monthly payments. In addition to providing the option to pay monthly, Exosite also has some customers, who pay annually. Moreover, Oracle has payment interval options from one month to paying once every five years, as this company is mostly concerned with customer lifetime value. All in all, seven of the ten companies, which answered this question, use the pay per device revenue stream. Company A didn't provide answers for this building block, or the ones that follow it, and for this reason, the number of respondents per question drops to ten for this, and the remaining four building blocks.

The remaining three companies use different forms of usage-based revenue. For example, Exosite’s revenue model is based on not only how many devices the customer uses, but also on how many resources and how much data storage is used. Furthermore, Samsung charges for the number of messages that the devices are sending to the platform, and BaseN charges the customer by transactions per second. In this context, transaction means line(s) of text that can come from a single sensor, or a combination of sensors. It refers to any kind of a scenario, where BaseN receives process data from the customer.

The pricing of these aforementioned revenue streams is dynamic for all of the interviewed companies. This means that the price can be negotiated, and a higher price typically has a better price per device. The transfer of money happens either through credit card payments or wire transfers, with four of the interviewed companies enabling both options.

While the different pay-per-options are the most important revenue streams for the interviewed companies, some of them also make money in additional ways. For example, Ubidots and Cumulocity earn a small amount of revenue for on site training and project support respectively, while Company B, Tibbo and Eurotech also sell IoT-related hardware. Eurotech and Tibbo are different from the other interviewed companies in that they have three tiers of revenue streams, where the pay-per-model is the most important. Eurotech also obtains revenue from selling hardware related to the platform, and from professional services, which means that they charge for consulting the customer on developing the optimal IoT solution. Furthermore, Tibbo also makes money from professional services, and their third revenue stream comes from delivering turn-key projects.

In this building block, the findings are very similar between my and Dijkman et al.’s (2015) results in that they both show the importance of usage based revenue for IoT business models. Dijkman et al.’s (2015) findings show that usage fees are an important type in this building block, and it is also the second most important type in this building block according to my findings. The most important type according to my findings is the pay per device revenue stream, which can also be seen as a form of usage based revenue: You pay as you connect devices to the platform, and a greater number of devices means a greater level of platform usage. The other significant types in this building block according to Dijkman et al. (2015) are subscription fees and asset sale. Subscription fees are not among my findings, but Eurotech, Company B and Tibbo sell hardware, i.e. they sell assets. Furthermore, Tibbo performs turn-key projects, which include start-up and installation fees that are types in this building block according to Dijkman et al.'s (2015) results. Beyond these aspects, there are no similarities between the findings of the two studies as the remaining types within this building block according to Dijkman et al. (2015) are lending/renting/leasing, licensing, advertising, and brokerage fees.

4.6. Key Resources

The interviewed companies use a very similar set of key resources that is mostly centered on human resources. Indeed, the most common key resources are development and sales, which were mentioned by all ten companies. These two resources make up the bulk of the key resources for the interviewed companies. Furthermore, Exosite, Ubidots and Cumulocity talked about data centers, Oracle acknowledged marketing, Company C mentioned hardware and Exosite mentioned support resources. Additionally, Oracle and BaseN mentioned that product management is a key resource in their business model, and Eurotech mentioned consultancy as a separate key resource.

The respondents also stated that human resources are the most important key resources for their business models with the exception of Oracle and BaseN, who stated that product management is the most important resource for their business models. Five of the interviewed companies said that development of the platform is the most important key resource. As Agustin Pelaez from Ubidots said: "if you have a product that is good enough to sell itself, you don't need a lot of marketing dollars." This development includes software and back-end development. Moreover, Company C and Exosite said that human resources are the most important key resource, without elaborating on what section within human resources is the most important. Finally, Eurotech stated that consultancy is the most important key resource for them, but that their solution can't be done without all of the resources.

Dijkman et al.'s (2015) results show that software and employee capabilities are the most important types within this building block. This is similar to my findings as development, which includes software development, was mentioned by all ten respondents. Moreover, employee capabilities are related to human resources, which were also mentioned by all ten of my respondents. Dijkman et al.'s (2015) study also found that physical resources are a type in this building block, and my respondents talked about data centers and hardware, which are physical resources. However, Dijkman et al.’s (2015) results do not mention sales, which is a significant difference, because all ten of my respondents mentioned that sales are a key resource within their business model. Dijkman et al.’s (2015) findings also include the types of relations, intellectual property and financial resources, which are absent in my findings. However, the similarities of the findings between the two studies are significant in that both show the importance of software development and human resources. Physical resources are also noteworthy, as they were mentioned by three of my respondents and also show up in Dijkman et al.’s (2015) findings.

4.7. Key Activities

The answers related to the key activities building block are similar to those in the last section, as seven of the interviewed companies talked about both software development and sales as also being their key activities. Interestingly, support activities are an important type within this building block, as these were mentioned by five respondents. Other key activities that were mentioned are quality assurance and partnership activities (Exosite), marketing (Cumulocity and Tibbo) and product management (Oracle).

When I asked the interviewed companies what is the most important key activity for their business model, I received a variety of answers. Three of them stated that software development and engineering are the most important key activities, while three others said that it is the customer support, consultancy and maintenance activity. Company B asserted that the most important activity changes over time: at first it’s engineering, but this moves to marketing, business development and sales once the product is established and mature. Once these are going well, customer service rises in importance.

Oracle and BaseN explained that sales is the most important activity. Indeed, Pasi Hurri from BaseN said that “If you can get the trust, you will figure out the product somehow.” This is in stark contrast with how Pelaez from Ubidots asserted that development is the most important resource, because “if you have a product that is good enough to sell itself, you don’t need a lot of marketing dollars.” Finally, Polyakov from Tibbo thinks that software development is the most important activity, as he stated that “If the software isn’t good enough, you can spend whatever money for trying to sell it, but it won’t work. If it’s not somehow better than the competition.” These different viewpoints are interesting, because they reveal opposite viewpoints on this aspect of the business model, even though the companies are offering the same product; an IoT platform.

Dijkman et al.'s (2015) research found that product development is the most important type within the key activities building block. It is not linked to any of the types that show up in this building block in my research. Dijkman et al.'s (2015) types for this building block also include software development, which was found to be the most important type in my study, along with sales. The other types in this building block according to Dijkman et al. (2015) are customer development, service, implementation, platform development, sales, marketing, partner management and logistics. Thus, the other similarities between the findings of the two studies are that sales, marketing and partner management were also discovered to be types within this building block in my study. However, sales, which is an important type in this building block according to my findings, is a minor type according to Dijkman et al.'s (2015) findings. Furthermore, customer development, service, implementation, platform development and logistics are not among my findings for this building block. Therefore, the findings of the two studies are different for this building block, with the exception of software development, sales, marketing and partner management.

4.8. Key Partners

The interviewed companies have a number of partners they are working with to bring the solution to life, and the complexity of the partner network of some of the interviewed companies provides credibility to the network perspective literature that was reviewed in section 2.4. For example, Samsung's partner network includes four different kinds of partners: The first includes systems integrators, distributors, and technical partners, who help with developing the solution. The second is ecosystem partners that are developing additional modules and additional services on top of the platform, to help enrich the offer that Samsung is providing to the market. An example of this would be developing connectors between the platform, SAP and Salesforce. Thirdly, marketing partners help improve the way Samsung is presenting the solution to its customers. Finally, Samsung has sales partners that are bringing the company leads, because they can not engage with everybody directly.

Systems integrators and hardware companies are the types of partners that were mentioned the most, as six respondents said that they are partnering up with these kinds of companies. Moreover, software / application partners and technical / technological partners are used by three of the interviewees. Other kinds of partners that were mentioned are communications partners (Exosite and Eurotech) as well as service design companies (Exosite and Oracle). Finally, individual respondents are partnered up with analytics partners, automation companies, engineering companies, OEMs, and marketing partners.

The interviewed companies leverage these partners to obtain different resources, the most common of which are sales, as was discussed in section 4.2.3. Furthermore, Oracle, Tibbo and BaseN stated that their partners enable them to understand different customers, verticals, and country markets better. Another important resource that the respondents said that they obtain through their partners is hosting capacity and data centers. Finally, the partners of the interviewed companies also enable them to obtain SIM cards, connectivity management services or hardware such as industrial modules.

The most important partners in Dijkman et al.'s (2015) study are software developers, launching customers, data interpretation and hardware producers. The only similarity between these and my findings is that hardware companies are significant in both studies. Three of my respondents talked about software partners, but they are not an important type in this building block according to my findings. Dijkman et al.'s (2015) findings also include service partners, and service design companies were mentioned by two of my respondents. However, launching customers is not among my findings, and the type in my study that is the closest to data interpretation is analytics partners. Furthermore, there are no similarities between the remaining types in my and Dijkman et al.'s (2015) studies as the remaining types, which are distributors, other suppliers and logistics, are not among my findings for this building block. Dijkman et al.'s (2015) findings also do not mention systems integrators, which is the type that was mentioned the most frequently by my respondents, along with hardware companies. Thus, there is little in common between the findings of the two studies beyond hardware companies, which were found to be an important type in this building block in both studies.

4.9. Cost Structure

There are some differences in the cost structures of the interviewed companies, but human resource costs are a significant cost factor for all of them. Indeed, seven respondents said that it is the largest cost, making up some 80-90 percent of the overall costs. Oracle stated that their sales force, which belongs to human resources, is the biggest expense in the business model of their IoT platform. Development costs are the largest item within cost structure for the other six respondents, who mentioned that human resources are the largest cost. For these seven companies, the remaining 10-20 percent of the overall costs come from infrastructure fees such as data center, data storage and server costs, components, as well as back office costs, and marketing. The remaining three companies, who mentioned human resources, did not specify which part within human resources contributes the most to overall costs.

BaseN and Eurotech said that hardware costs are the most important cost factor for them, and the difference comes from the fact that these companies create their own hardware, whereas most of the other companies don't. For BaseN, it's a strategic choice, because they want to be able to create an end to end solution for their customers that doesn't depend on other companies. For this reason, the company creates its own hardware instead of relying on suppliers. Even though hardware is the largest cost in BaseN's business model, human resource costs, which consist of sales and product management, still make up 40 percent of overall costs. Tara MacLachlan from Eurotech explained that for one project she did, the costs consisted 35 percent of communication costs, 45 percent of hardware costs, and 20 percent of platform and application costs. Finally, Samsung said that the largest costs come from hosting and maintaining the platform, but didn't provide further details about the cost structure.

The findings of the two studies have some similarities in terms of the cost structure building block. My results indicate that human resources are the most important type within this building block, and while Dijkman et al. (2015) do not mention human resources explicitly, they do talk about personnel costs. However, it is not an important type according to their results. The most important type in the cost structure building block according to Dijkman et al.'s (2015) study is product development costs, and apart from Oracle, all of my respondents said that development costs are the largest cost item within human resources. However, Dijkman et al. (2015) do not specify how much of the product development costs of their respondents are tied to the developers and their salaries, and for this reason it is impossible to say whether the product development costs in Dijkman et al.'s (2015) study should be considered a human resource cost or not.

Hardware costs were mentioned by two of my respondents, and they are also mentioned in Dijkman et al.'s (2015) study as hardware/production cost, although they are not an important type according to their findings. Moreover, Dijkman et al.'s (2015) findings mention IT cost, which is related to the data center and infrastructure costs that showed up in my findings. Finally, sales and marketing were discovered as types in this building block in both my and Dijkman et al.'s (2015) studies, but my respondents did not talk about logistics costs, while Dijkman et al.'s (2015) did. Thus, there are some similarities between the findings of the two studies as far as this building block is concerned, but these similarities mostly exist between types that were discovered to be less important in both studies.

4.10. The most important building block

In addition to questions about the different building blocks, Dijkman et al.'s (2015) study also included the following question: "What would be the most important building block to make this product successful?" I asked my respondents the same question, but I substituted the word platform for product. Six of the respondents said that this question is difficult to answer, as all of the nine building blocks are important. Indeed, Company B was unable to pick just one building block, and instead stated that "it's the combination." Furthermore, three of the respondents named two building blocks, because they were unable to name just one. Nevertheless, value propositions and customer relationships were the most common answers, as they were mentioned by four of the interviewed companies. For example, Pelaez from Ubidots stated that value propositions is the most important building block, because it defines the rest of the resources that you build around the business model. Furthermore, Polyakov from Tibbo described the importance of value propositions in the following manner:

"if you're able to build a technologically excellent product, which is better than the rest, people will after all find you somehow. I mean they start telling about you, they are likely to start using and showing it to others. So after all, if your product is good, then it's, the business is going to grow pretty fast."

Customer relationships were also mentioned by four respondents. Eurotech described customer relationships by saying that it's important to define the solution well in the beginning so that each party agrees to what is delivered. Apart from value propositions and customer relationships, channels were mentioned by two respondents and key resources were mentioned by one respondent.

Both the interview and survey results in Dijkman et al.’s (2015) study show that value propositions are the most important building block for IoT business models. While all nine building blocks were mentioned by at least some of the respondents, value propositions stand out from the rest. The importance levels of the other building blocks in Dijkman et al.’s (2015) survey are approximately at the same level, although channels were discovered to be the least important building block. However, in their interviews, customer relationships and key partners were the building blocks that were mentioned as the most important building block the most frequently after value propositions, with six and five mentions respectively.

This comparison shows clear similarities between the findings of Dijkman et al. (2015), and mine. Value propositions and customer relationships show up in both studies, and value propositions was discovered to be the most important business model building block in both, albeit it shares this position with customer relationships in my study. Moreover, customer relationships were also mentioned as the most important building block by six of Dijkman et al.’s (2015) interview respondents, making it the most frequently mentioned building block after value propositions.

Dijkman et al. (2015) carried out eleven interviews, but value propositions, customer relationships and key partners were mentioned by nine, six, and five respondents respectively. It is notable that at least some of Dijkman et al.’s (2015) respondents were also unable or unwilling to identify a single, most important building block. Instead, they mentioned several building blocks, and this occurred during my interviews as well. The differences between the two studies are that key partners, which were mentioned third most frequently by Dijkman et al.’s (2015) respondents, were not mentioned even once by my respondents. Furthermore, channels were said to be the most important building block by two of my respondents, but it is the least important building block according to Dijkman et al.’s (2015) study. Finally, Dijkman et al.’s (2015) findings do not mention key resources, but they were mentioned by one of my respondents. Thus, even though there are differences between the findings of the two studies, the main findings are similar in that both identify value propositions and customer relationships as the most important building blocks for IoT business models.

4.11. Summary

There are both noticeable similarities and differences between the findings of my study and Dijkman et al.'s (2015) study. These findings have been summarized into figures four and five, which can be seen below. In figure four, which represents Dijkman et al.'s (2015) findings, the types are in a descending order, and the types that received the highest score from the respondents are at the top of their respective building block. In this context, high score means that a high number respondents agreed on the importance of the type on a five-point Likert scale ranging from "strongly disagree" to "strongly agree". Furthermore, the types that scored considerably higher than the average score in their building block are either above or to the left of the type with the gray background. This gray background is absent in the customer segments building block, because no type was found to be significantly more important in this building block.

In figure five, which depicts my findings, the types are grouped in order of importance by the number of times they were mentioned during the interviews. In the key resources, key activities and channels building blocks, which included the questions: "Which resource / activity is the most important?", and "which channels work the best?", I have also included the input from these answers into the ranking.

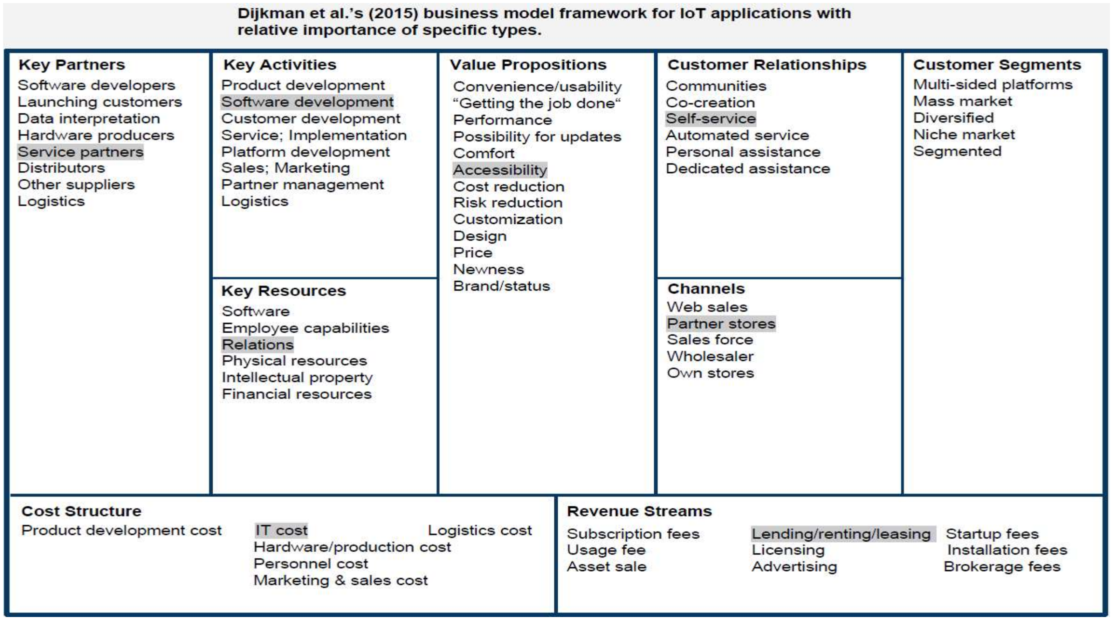

Figure 4: Dijkman et al.'s (2015) business model framework for IoT applications with relative importance of specific types

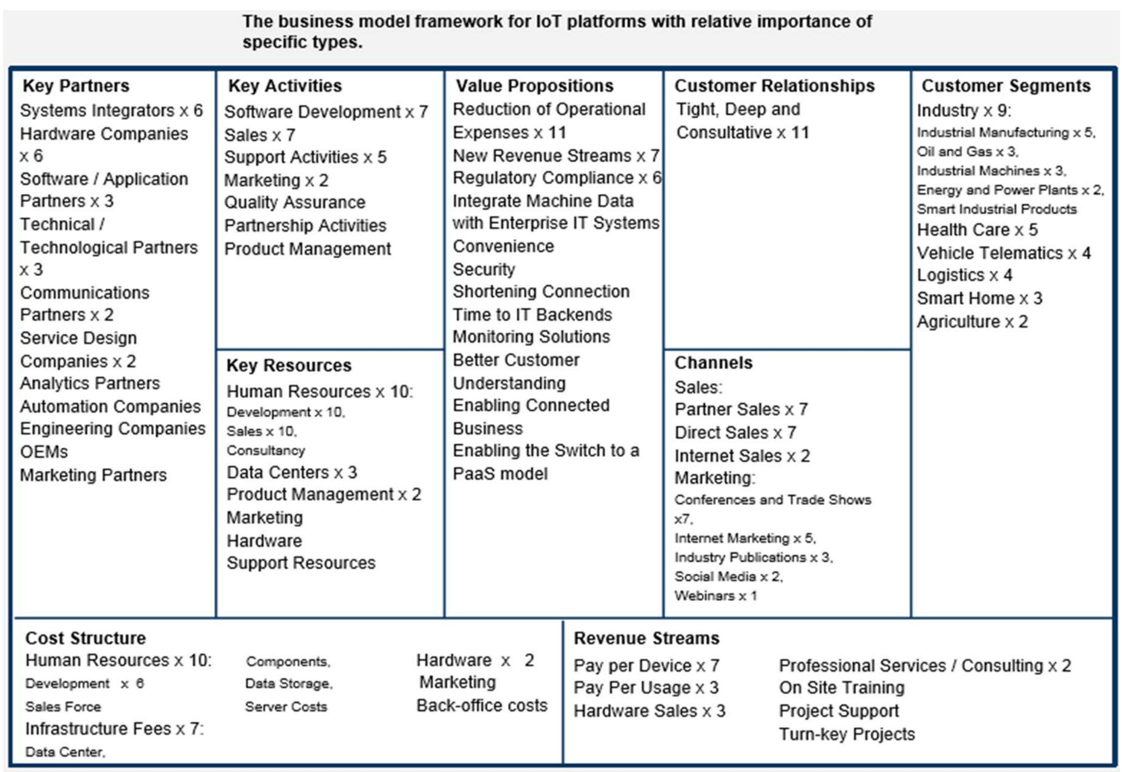

Figure 5: The business model framework for IoT platforms with relative importance of specific types

In the customer segments building block, Dijkman et al. (2015) discovered the following types: Multi-sided platforms, mass market, diversified, niche market and segmented. Furthermore, these types were discovered to be approximately equally important, as no types scored considerably higher than the average score. My findings do not support Dijkman et al.'s (2015) findings in this building block, because there are no similar types between our findings. The only type in Dijkman et al.'s (2015) findings that slightly resembles mine is diversified, as all of my respondents serve multiple customer segments. For the IoT platform providers, which I interviewed, the most important type in this building block is industry, with nine out of eleven respondents serving industrial customers.

Dijkman et al. (2015) discovered that convenience / usability, "getting the job done", performance, possibility for updates and comfort are the most important types within the value propositions building block. For the most part, my findings for this building block do not support Dijkman et al.'s (2015) findings, as these types are either absent or unimportant types according to my findings. The only notable similarity between the major types between the two studies is that reduction of operational expenses, which was mentioned by all of my respondents, is related to performance. In addition to this type, new revenue streams and regulatory compliance were discovered to be the most important types in this building block in my study.

Web sales are the most important type within the channels building block according to Dijkman et al.'s (2015) findings. My findings do not support this, as partner sales and direct sales are the most important channels for my respondents. Internet sales were mentioned by two of my respondents, and the internet is also used in marketing, but it is not an important type within this building block according to my findings.

In the customer relationships building block, Dijkman et al.'s (2015) findings show that communities and co-creation are the most important types. My respondents did not mention communities, so my findings do not support those of Dijkman et al. (2015) in that respect. However, it is unclear what co-creation means in Dijkman et al.'s (2015) study, and for that reason, it is difficult to discern whether my findings support it or not. All of my respondents talked about deep, tight and consultative customer relationships, so it is the most important type within this building block according to my study. Indeed, it is the only type that my respondents mentioned. Conversely, Dijkman et al.'s (2015) findings show both tight customer relationships (personal and dedicated assistance), and loose customer relationships (self-service and automated service). This implies that customer relationships of IoT platforms are characterized by deep and tight relationships, whereas the customer relationships of generic IoT applications include both tight and loose customer relationships.

Dijkman et al. (2015) discovered that subscription fees, usage fee and asset sale are the most important types within the revenue streams building block. While my results do not include subscription fees, they do support Dijkman et al. (2015) in that usage fees were also discovered to be important in my study, and three of my respondents also sell assets. While there is little in common between the findings of the two studies in terms of the less important types, the similarities between the most important types are important. They suggest that usage fees are important revenue streams for both IoT platforms and generic IoT applications. Moreover, the presence of asset sale in both studies implies that this traditional way of capturing value is still relevant for IoT business models, even though they enable PaaS and servitization.

Dijkman et al. (2015) found that software and employee capabilities are the most important types in the key resources building block. My findings support this in that employee capabilities are related to human resources, which were mentioned by all ten of my respondents. Moreover, development, which includes software development, was also mentioned by all of my respondents. However, Dijkman et al. (2015) did not find sales to be an important type within this building block, but they were mentioned by all of my respondents. In this sense, my findings contradict those of Dijkman et al. (2015). Nevertheless, the findings of the two studies are similar in that employee capabilities and software were discovered to be important types in this building block in both studies.

In the key activities building block, Dijkman et al. (2015) found that product development is the most important type. It is not linked to any of the types that were found to be important in my study, which means that my findings do not support those of Dijkman et al. (2015) in this building block. Indeed, my results show that the most important types in this building block are software development and sales. Software development can be thought of as product development, if the product the company sells is software, but the fact that Dijkman et al. (2015) show product development and software development as separate types in this building block means that the two should not be mixed in this context.

Dijkman et al. (2015) found that software developers, launching customers, data interpretation and hardware producers are important types in the key partners building block. Hardware companies are also important according to my findings, but they do not support those of Dijkman et al. (2015) otherwise. Software partners were mentioned by three of my respondents, but that does not constitute an important type in my study. In addition to hardware companies, my results show that systems integrators are important partners for IoT platform companies.

Product development cost is the only important type in the cost structure building block according to Dijkman et al. (2015). My findings support this in that six of my respondents also talked about development costs. However, software development is more important for my respondents than product development. Moreover, human resources, which are an important type in this building block according to my study, are a minor type according to Dijkman et al. (2015). In this way, my findings contradict those of Dijkman et al. (2015) and as a whole, the findings of the two studies in terms of the important types in this building block are dissimilar.

Dijkman et al.'s (2015) study found that value propositions, customer relationships and key partners are the most important building blocks for IoT business models. My findings support this in that value propositions and customer relationships were also discovered to be the most important building blocks in my study. Furthermore, Dijkman et al.'s (2015) respondents were either unable or unwilling to identify a single building block that is the most important, and instead mentioned several. This also happened during my research, and thus the findings of the two studies are similar in terms of the most important building block, even though key partners were not found to be important in my study.

5 Discussion

The initial research question that I outlined in the research plan was: Which business model building blocks and types are the most important when developing business models for IoT applications? However, studying all kinds of IoT applications was beyond the scope of this thesis, so I changed my focus to studying the business models of IoT platforms. The business models of IoT platforms were studied by conducting eleven semi-structured interviews with IoT platform companies. The interview questions followed the premise of the component view, which asserts that a business model of a company can be analyzed by breaking it down into its building blocks, and their associated types. Thus, the first research question is:

Research question one: Which business model building blocks and types are the most important when developing business models for IoT platforms?

My research results show that value propositions and customer relationships are the most important building blocks for the business models of IoT platforms. It should also be noted that most of my respondents mentioned several building blocks as the most important, instead of just one, because they were unable to name just one. In addition to value propositions and customer relationships, two interviewees mentioned channels, and one interviewee mentioned key resources as the most important building blocks, respectively. The most important types for each business model building block are:

- Customer Segments: Industrial customers are the most important customer segment type for IoT platform companies. Within industry, the interviewed companies serve customers from a range of areas including industrial manufacturing, oil and gas, industrial machines, energy and power plants as well as smart industrial products.
- Value Propositions: Reduction of operational expenses, new revenue streams and regulatory compliance are the most important types in this building block. Reduction of operational expenses is the most important one, as it was mentioned by all of the interviewees. An example of this type is predictive maintenance, which means that companies are able to supervise the performance of their devices, and respond proactively, if they see that a malfunction may occur. Furthermore,

new revenue streams were mentioned by seven respondents, and regulatory compliance was mentioned by six. IoT platform companies enable their customers to create new revenue streams by e.g. enabling them to sell the data that is gathered from the devices. Moreover, regulatory compliance means that the interviewed companies help their customer to comply with regulatory requirements.

- Channels: Partner sales and direct sales are the most important sales channels. In reaching their customers, the interviewed companies leverage their partner networks extensively, which supports the network perspective. Nevertheless, direct sales are also an important channel, as they were mentioned by seven respondents as well. Conferences and trade shows are the most important marketing channels, which shows that this traditional way of marketing is also important for the business models of IoT platforms.
- Customer Relationships: The most important type was the easiest to identify in this building block as all eleven interviewees stated that their customer relationships are tight, deep and consultative. IoT is still in its infancy, and many of the interviewed companies' customers are implementing IoT for the first time. Thus, these customers need to be consulted on how they can utilize IoT most effectively in their businesses. Finally, switching to IoT is a strategic decision, which can completely change the business model of the customer, and this change process requires a deep partnership between the IoT platform company, and the customer.
- Revenue Streams: Pay per device and pay per usage are the most important types of revenue streams for the interviewed IoT platform companies. Under these revenue models, the customers pay the IoT platform company for the number of devices they connect to the platform, or for the degree to which they are using the platform. However, these pricing models are dynamic as the price per device is often negotiable, and IoT platform companies have different ways of gauging the price of data transfer.
- Key Resources: Human resources are the most important key resources for the interviewed IoT platform companies, and within human resources, the most important key resources are development and sales. Osterwalder and Pigneur (2010) asserted that a business model is the way in which a company "creates, delivers and captures value", and these two key resources enable the interviewed companies to accomplish these activities: Development of the platform enables the

IoT platform companies to create value, while sales resources enable them to capture it.

- Key Activities: Software development and sales were discovered to be the most important types within this building block. These findings are very similar to those of the key resources building block, which implies a relationship between the two. When studying the key activities of the interviewed companies, I encountered two schools of thought: One, which states that development is the most important activity, because once you have a superior product, sales will take care of itself. However, I also encountered the view that sales is the most important activity, because once you have the trust of the customer, you will figure out the product somehow. It is interesting that companies, which create similar platforms, have opposing viewpoints about this subject.
- Key Partners: Systems integrators and hardware companies are the most important key partners for the interviewed IoT platform companies. Studying the key partners of the interviewees verified the network perspective, as these companies utilize extensive partner networks. The interviewed companies leverage their partners to obtain many different kinds of resources including sales, hardware, analytics, communications and service design.
- Cost Structure: Human resources are the most important costs for the interviewed IoT platform companies, and within human resources, the most important element is development. Since both development and sales are the most important key resources, it is surprising that sales were not discovered to be among the most important types in this building block. This implies that the salaries of developers are higher than those of sales people. Furthermore, infrastructure fees are also an important type within this building block, as they were mentioned by seven interviewees. For the interviewed companies, infrastructure fees refer to data center, components, data storage and server costs.

In addition to studying the business models of IoT platforms, I wanted to compare the business models of IoT platforms with those of generic IoT applications. Thus, I compared my findings with those of Dijkman et al. (2015), who studied the business models of generic IoT applications. Moreover, I utilized the same interview questions as Dijkman et al. (2015) to maximize comparability between the two studies. The desire to compare the business models of IoT platforms and generic IoT applications lead to the second research question:

Research question two: How are the business models of IoT platforms different from those of generic IoT applications?

By comparing my findings with those of Dijkman et al. (2015), who studied the business models of generic IoT applications, I was able to answer my second research question. The main discovery is that as a whole, the business models of IoT platforms and generic IoT applications are quite different from each other, because the findings are different for most of the nine building blocks. This is especially true for the types that were discovered to be important in each building block. In almost all of the building blocks, there were types, which were similar to each other, and which could be found in both studies. However, it was rare that the type that was discovered to be important in my study would also be important in Dijkman et al.'s (2015) study, or vice versa. For example, convenience was discovered to be one of the most important types within Dijkman et al.'s (2015) study, but it was only mentioned by one of my interviewees. The most important types are types that were mentioned the most frequently, and thus give the best indication of what is most salient in a given building block. For this reason, I discerned that it is best to focus on the most important types when comparing the findings of the two studies.

My findings contradict those of Dijkman et al. (2015) in terms of the customer segments, value propositions, channels, key activities and cost structure building blocks. Within these building blocks, there were no types that were discovered to be important in both my and Dijkman et al.'s (2015) studies. Thus, we can say that the business models of IoT platforms are different from those of generic IoT applications in terms of these building blocks. However, there are slight similarities between the findings in the customer relationships and key partners building blocks. For example, the customer relationships of IoT platform companies were discovered to be deep, tight and consultative, whereas the customer relationships of generic IoT companies include both deep and loose customer relationships. In the key partners building block, both studies discovered that hardware producers are an important type. This means that hardware producers are important partners for the business models of both IoT platforms and generic IoT applications.

The business models of IoT platforms were discovered to be the most similar to the business models of generic IoT applications in terms of the key resources and revenue streams building blocks. Both IoT platforms and generic IoT applications capture value through usage-based revenue, although for IoT platforms, this also means charging per device as they are connected to the platform. Finally, software development and employee capabilities were discovered to be the most important types of key resources in both mine and Dijkman et al.'s (2015) study.

To summarize the answer to research question two, the business models of IoT platforms and generic IoT applications were discovered to be mostly dissimilar. A comparison of the findings between my and Dijkman et al.'s (2015) studies shows that the majority of the building blocks have no important types in common. These building blocks are customer segments, value propositions, channels, key activities and cost structure. The similarities exist mostly in the revenue streams and key resources building blocks, as pay per usage, software and employee capabilities were discovered to be important types in both studies. Moreover, there are some similarities in the key partners and customer relationships building blocks, because both studies find that hardware partners and tight customer relationships are important types within them. It is also noteworthy that Dijkman et al's (2015) respondents also provided multiple answers, when they were asked about the most important building block in their business model. This means that for both generic IoT application companies, and IoT platform companies, there are several business model building blocks, which are the most important.

5.1. Theoretical Implications

The main part of the findings consisted of my inquiry into the nature of IoT platforms' business models to find the building blocks and types that are the most important for the business models of IoT platforms. Furthermore, I have compared my findings with those of Dijkman et al. (2015) to determine the differences and similarities between the business models of IoT platforms and generic IoT applications. However, my interviewees also shared insights, which pertain to the theoretical concepts that were discussed in the literature review. These will be reviewed next.

5.1.1. Product as a service business models

Gonçalves and Dobbelaere (2010) as well as Kortuem et al. (2010) assert that IoT enables companies to sell their products as services and charge their customers based on how much they use the product. The interviews verified this assertion as not only are the interviewed companies utilizing usage-based revenue streams, but their customers are also implementing PaaS. As was stated before, Salminen from Oracle asserted that ultimately companies wish to become service companies, because they seek to obtain higher margins. Salminen also agrees with McKinsey and Company (2015) in that service business models yield the opportunity to create a close business relationship that is difficult for competitors to fracture. Furthermore, during the interviews it was discovered that having steady revenue streams is better from a reporting perspective than product sales, which are less predictable. This is especially true with large industrial products such as cranes or motors, because they are expensive and typically have long sales cycles. My respondents told me several examples of how their customers are implementing PaaS. For example, the representative from Company B said the following:

"There is this concept called usage-based insurance, where insurance rates for the car vary depending on your driver behavior. Then we could see how fast he went, how often he went over the speed limit, because we can overlay it on maps from Google with the speed limit and send alarms when it goes too fast. We can track acceleration, deceleration, G-forces when he turns. So we can not only adjust the insurance rates, but companies can monitor how their employees are behaving in the cars."

Moreover, when I asked whether he sees servitization happening, Hurri from BaseN gave the following answer:

"We have modelled to many customers this kind of thing that for instance Konecranes that is selling harbour cranes and very heavy industry cranes that they are now looking into a model that they could just sell lifts, so how many times you are lifting things. And not selling the crane at all, but selling only the service to the customer."

Finally, MacLachlan from Eurotech described the business models of connected products in the following way:

“Everything that we're doing, everything that IoT is doing, is driving businesses towards delivering service rather than product. So let me take the example of the mentioned large industrial printing machines. If you sell a machine to a customer, you've got the loyalty of that customer for the duration they have that machine. They can then go and buy different machines somewhere else. If you don't sell the machine, but you give the customer the machine and charge them to use it, you can extend the life cycle of the customer loyalty. Everything within IoT that we're doing with IoT as a service, is driving my customers towards revenue business models that contract you with a customer that the contract - especially in the case of large assets, could be 7, 10, 12, 15 years long. It means that you have got a revenue stream in your business that you can rely on month in, month out for 15 years.“

As these examples illustrate, companies are already utilizing IoT and implementing PaaS models. This also gives credibility to Bucherer and Uckelmann (2011), who hypothesized that PaaS is one of the business model types enabled by IoT. However, due to the privacy, security and interoperability risks, it is still uncertain to what extent different companies will embrace IoT and PaaS. Indeed, Jari Salminen from Cumulocity commented on this by saying that:

“I think it depends also on the maturity of the whole market. At the moment lot of the people we speak to don’t really know how large percentage of their devices they will connect eventually. And as they don’t know, they would oftern rather start with pay per use model. But if you know that you will connect say 10 000 devices, you might do the math and think that paying up-front a larger amount will save on the long term. So I think the preferred pricing model depends on how mature the business is at looking at IoT and how clear their plans are.”

Salminen from Oracle also posited that the maturity of the business is a factor in PaaS implementation: “The more mature a company is in utilizing IoT, the more likely it is to bear the risk of its devices breaking down in return of obtaining a higher margin.” While Salminen from Oracle was talking about maturity from the device manufacturer’s perspective, and Salminen from Cumulocity was talking about maturity from the IoT platform company's customer's perspective, both statements display the influence of IoT maturity on companies' decision making when they are considering implementing PaaS.

Moving to PaaS also means that the manufacturer retains ownership of the device, and that it remains in the manufacturer's balance sheet. Porter and Heppelmann (2015) state that gathering and analyzing data on the usage and performance of their devices enables companies to increase their expertise and understanding of their businesses, products and customers. Salminen from Oracle agrees on this, and stated that: "When you have the best data, you have a great opportunity to create the best operation." He also said that while companies often make the switch to PaaS in order to obtain higher margins, the ability to maintain the devices efficiently is needed for achieving greater profit levels. However, when companies retain control of their devices, they can also control the maintenance of those devices, and even perform predictive maintenance, which is conducive to efficiency. Finally, Salminen posits that changing a company's revenue model to a PaaS model is a large undertaking that typically requires an extensive internal change program.

5.1.2. The Network Perspective

As was established before, the view that IoT business models function as networks and ecosystems has gained a great deal of traction in literature (e.g. Westerlund et al. 2014; Glova et al. 2014; Pisano et al., 2015; Andersson and Mattsson, 2015). My findings support this view, as the interviewed companies are utilizing extensive partner networks in order to execute their business models. Furthermore, the partner channel was even discovered to be the most important sales channel, along with direct sales. Delalande from Samsung had this to say about the role of their partners:

"I think it's quite critical to have those partners, because part of the, we all know that, like you can not develop IoT on your own, so you need to have solutions and terms that are open for partners and open for third parties. So that's why the role of the ecosystem is very critical, because it help us to, yeah, to make our offer more attractive to our customers by bringing up some additional solutions that we can not develop ourselves."

The partner ecosystem is important for all the studied companies. For example, MacLachlan from Eurotech stated that "the third part of my job is to build up the partner ecosystem." Moreover, the interviews revealed further examples of how utilizing IoT can change the nature of partnership between companies. For example, Salminen from Oracle told me that Rolls-Royce is supplying airplane engines to an Australian airline called Qantas. Qantas pays Rolls-Royce for every hour that its planes are in the air, and Rolls-Royce retains ownership of its engines. In 2010, an engine of a Qantas passenger plane exploded, when the plane was in the air. The plane landed safely, but Rolls-Royce had to take a larger role in the crisis management of this incident, than if it had merely sold the engine to Qantas. So while IoT enabled PaaS business models yield higher margins and steady revenues, they may also require companies to share a part of the risk with the customer.

Another interesting example came from Oracle's Salminen. He stated that ultimately IoT enables charging for output: Rolls-Royce charges for the time its engines keep planes in the air, and Xerox charges for the papers that its printers print. If we apply this thinking to Valmet, which manufactures paper machines and UPM, which manufactures paper, we come to a situation where Valmet is charging for the paper that is being produced, and it is no longer clear who is producing the paper. If Valmet is in fact the producer of the paper, the labor is now under a different collective agreement, which in turn impacts the labor union of paper workers. While it is currently uncertain, whether this type of a situation will arise, this example shows that the changed nature of business relationships between companies can have ramifications for other stakeholders as well.

Finally, Polyakov from Tibbo posited that the line between customer and partner can blur in the IoT platform business. For example, large customers can become partners, and different partners can have an increasingly large role in the business:

"And even the system integration companies, they put a lot of efforts into such kind of relationship, because they are not only marketing our solutions and selling them, but also they're, again, they're building their own products or reference solutions based on our platform, so they directly invest into the development plus, they of course invest into marketing and sales and stuff."

As these examples illustrate, the network perspective holds true for the interviewed IoT platform companies. My respondents did not say that they have used business model design frameworks such as those developed by e.g. Allee (2000), Gordijn and Akkerman

(2001) or Westerlund et al. (2014), which embrace this perspective. Instead, they seem to focus on creating the maximum amount of value, and working with partners that help them grow their business.

5.1.3. Business Model Development

Business model development has been found to be an iterative process, which involves testing and learning through trial and error (Magretta, 2002; Sosna et al. 2010; Teece, 2010; Pisano et al. 2015). The interview questions did not include questions about how the business model of the interviewed company developed over time, but Benson from Exosite mentioned that their market entry happened with the second iteration of the platform. Furthermore, he said that they "learned a lot of lessons from doing things like connected elevators and cat walks in buildings", and that they were able to leverage these learnings in further improving the platform. This finding supports the notion of business model development as an iterative learning process.

5.1.4. The Challenges of IoT

The interview questions also did not include questions about the challenges that currently face IoT, but during the interviews, I nevertheless received some insights about them. For example, Salminen from Cumulocity had the following to say about standardization:

"I think that standardization will have a big impact to IoT deployments. For customers this is just positive while for vendors it will have both positive and negative impact. One clear positive effect will be that it will be much easier and faster to connect things to the cloud than it is today removing unnecessary complexity. We already have some areas where we are able to just plug and play things into cloud, such as support for some fieldbus protocols, but for most of things you need to do specific integration work. And while standards make life easier for all, the obvious negative impact to vendors is that it will increase competition."

As was stated in the literature, the IoT field is currently unstandardized and interoperability issues affect it. While Miorandi et al. (2012), as well as Bandyopadhyay and Jaydip (2011) state that interoperability is necessary for harnessing the full value of IoT, this quote shows that companies, which operate in the IoT field may also benefit from interoperability issues and a lack of standardisation, because these also lower the amount of competition in the market.

Some of my respondents also said that they are influenced by privacy and security issues. For example, Tibbo usually runs its platform on site to avoid someone hacking into the customer's data, and BaseN also deploys the platform on site for military- and other security sensitive customers. Moreover, the interviewee from Company C stated the following about privacy:

"I think that in the long run, people will be very afraid of running, for example, stuff out of the US. There's already the European regulations kicking in about protection, privacy and so on. There have been the Snowden incidents, so countries get more concerned about where their data is. So, I think that will be like in the future, you know like very critical, and of course that means like they want to be in control, they want to own basically, because if you have a machine built up, they want to make business with their machine. So they don't want to give away the data and lose everything."

It is notable that even though the interview questions didn't include questions about the issues currently facing IoT, these topics still emerged during the interviews. This indicates that the challenges discussed in the literature are relevant and current. Finally, the inputs gained from the interviews reinforce the understanding that the challenges facing IoT are complex and multifaceted.

6 Conclusion

This thesis presents research about the business models of IoT platforms. This subject was studied through eleven semi-structured interviews, which lead to an understanding about the business model building blocks and types that are the most important for the business models of IoT platforms. These findings were also compared to the business model building blocks and types, which have been discovered to be the important for generic IoT applications. Thus, this thesis also provides insights about the differences between the business models of IoT platforms and generic IoT applications.

While the thesis does yield insights about the business models of IoT platforms and the differences between the business models of IoT platforms and generic IoT applications, the thesis is subject to limitations. The research approach used in this thesis is explorative and qualitative, and the number of interviews is restricted. Hence, this thesis lacks the power of discovering trends that comes from having hundreds of respondents or data points. The small number of observations also prevented the use of factor analysis or other statistical techniques, which could have been useful for obtaining further insights. My personal interpretation of the findings is also subjective, and affected by personal biases: A different researcher might have focused on different inputs, or interpreted the findings differently. Furthermore, the interviewed companies range from start-ups to large multinationals, and as such, the findings apply to a range of companies instead of being focused on companies of similar size. Finally, the IoT field is subject to change as IoT becomes more mature, which means that this thesis is not to be taken as a step-by-step guide for creating a business model for an IoT platform or a generic IoT application. Instead, it should be seen as a guide that helps practitioners and aspiring IoT entrepreneurs by providing knowledge of what kind of IoT business models have already been created. This knowledge can then be used in assessing what types each building block of the new business model could include.

IoT is a relatively new phenomenon, and there is room for further research in this field. Future research could focus on e.g. solving the challenges of IoT such as privacy, security or interoperability. Within interoperability, the incentives of companies to adopt externally developed standards is a good research area, as the companies that are currently operating inside IoT also benefit from the lack of interoperability. Furthermore, further research can also be done on IoT business models, and future research could focus on different fields of IoT applications, e.g. in health care, industry, or logistics. The business models of IoT applications in a given field can be studied through both qualitative and quantitative methods, and the resulting findings can be compared with existing literature to discover similarities and differences between the business models of different kinds of IoT applications. The network perspective could also be studied further in different industries to determine, whether this change is happening in all industries, or only in some of them. Finally, the transition from a traditional business model to a PaaS model warrants further research, as the benefits of PaaS are most likely interesting for many companies. Research into this field could illustrate not only the benefits and challenges that are related to switching to PaaS, but also the steps that are needed for making this transition.

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Appendix A: The Interview Questions

1. Questions about the company

a) Size?

b) Sector?

c) B2B or B2C?

d) Product or Service?

2. Questions about the IoT platform

a) Could you describe the IoT platform?

  i. How did you come to the idea?

  ii. How did the process of development and market entry go?

  iii. Do competitors also offer a platform like this?

b) Did this platform exist without being connected?

c) What is the age of the not connected version of this platform?

d) What is the age of the (new) connected platform?

3. Questions about the IoT platform’s business model building blocks

a) Customer segments

  i. Who are the most important customers? What is the focus group?

b) Value Propositions

  i. Which customer problems are you helping to solve?

  ii. Which customer needs are you satisfying?

  iii. What bundles of products and services are you offering to each Customer Segment?

c) Channels

  i. How are you reaching your customers?

  ii. How do they want to be reached?

  iii. Which ones work best?

d) Customer relationships

  i. What type of relationship do you have with your Customer Segments?

  ii. Is this different then Customers would expect the relationship to be? How?

e) Revenue streams

i. Which different revenue streams are used?

ii. What payment model(s) do you use?

iii. Are the prices fixed or dynamic?

iv. Does the customer earn or save money by using this platform? How?

f) Key Resources

i. Which resources are needed to create and offer your platform?

ii. Which resource is the most important?

g) Key Activities

i. Which activities are needed to create and offer your platform?

ii. Which activity is the most important?

h) Key partnerships

i. What kind of partners (other organizations) are partnered with to deliver the platform?

ii. Which Key Resources or Activities do you acquire from these partners?

i) Cost Structure

i. What are the most important cost factors in this business model?

ii. On what kind of cost structure is this business model based?

6. General questions on the business model of the IoT platform

a) What would be the most important building block to make this platform successful?

b) Are there any exceptions in which the business model is built up differently?

c) Are there other IoT products currently sold in your company?

i. If so, are the business models similar to the one of this platform or really different?

ii. What is different?

d) In general, how would you expect that business models of connected products will change in the future?

i. Which change have the biggest impact on companies (and on your company)?

ii. Which questions have to be answered by companies (and by your company)?

e) Is the platform considered to be successful by your company? In what sense is it successful?